MATERIALS & METHODS

THE METALWORKING INDUSTRIES' ENGINEERING MAGAZINE

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THE METALWORKING INDUSTRIES' ENGINEERING MAGAZINE

Volume 24, Number 3 September, 1946

Many of the laminated plastics can be cut, machined and formed like metals. Here a workman is sawing laminated plastic tubing preparatory to further machining. (Courtesy: Bakelite Corp.)

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Induction Heating Applied to Gearing
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Permanent Mold Casting of Gray Iron
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Radiant Heating
GRINDING: "Materials & Methods Manual" No. 20

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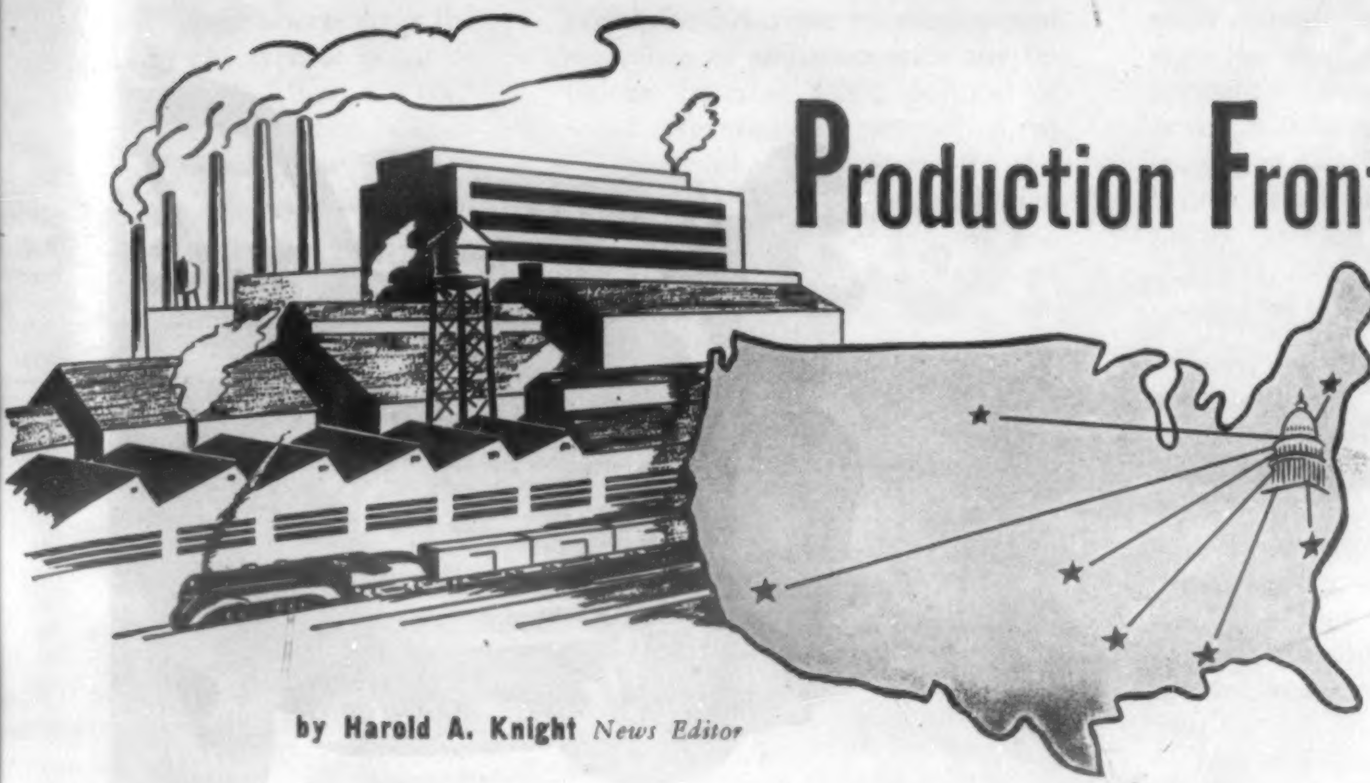
Production Frontiers



by **Harold A. Knight** *News Editor*

Anyway You Figure It: Production Is the Need

"The whole world is breaking its neck trying to emulate American production methods, and we're breaking our necks trying to run away from them." So spoke Eric A. Johnston recently. "The American union today which does not believe in full production is doomed to oblivion as something anti-social. The progressive viewpoint is one which puts production paramount and condemns the creed of scarcity as something to be dropped down a sinkhole."

Mr. Johnston lashed out against the opposition of many unions to incentives to production. He pointed out that the British prime minister called on British unions to drop any customs or rules which might hamper full production. He called on employers to do the same. France, too, has a pro-labor government, but even France is determined to raise its productivity per worker. French unions are underwriting full production.

Even Communistic Russia is employing capitalistic techniques in an all-out drive for production, continued Mr. Johnston. Russia has recognized the value of incentives and gone to extremes with them. There is a much greater difference between the income of the mediocre worker and the highly productive worker in Russia than in the United States.

Leaving Mr. Johnston, we learn that in Russia the prices of all manufactured goods were reduced an average of 40% on July 1—again a striking difference from price trends in our nation.

Need for ever-increasing production here is still the major topic where economists, politicians and management engineers congregate. We began the second half of 1946 with basic industries behind schedule on a scale from 21% for coal to over 73% for the automotive industry, according to the National Association of Manufacturers, which comments that since V-J Day 100,000,000 man-days have been wasted in strikes. Production of refined copper was 52% behind 1945; steel production lagged more than 40% behind practical capacity.

Another recognized economist comments on the "deplorably poor job of production" for the first half year —Leonard P. Ayres, vice president, Cleveland Trust Co., who cites drops of 27% revenue ton miles of Class 1 railroads, 22% in bituminous coal production and 37% in steel production. The worst production records are credited, in that order, to auto, sewing machine and refrigerator output. "We are trying to have a low production prosperity, and it can't be done," he concludes.

Overall Output Is Distinctly Higher

On the brighter side is the report of John D. Small, Civilian Production Administrator, who reported that our industrial output in June rose to a new post-war high, with prospects for July having reached the all-time pre-war record achieved in December, 1941. However, the June production was spotty with "good news for housewives", but less cheery word for the motorist and the farmer. June's good showing was due largely to swift comebacks in the coal and steel industries, high output of many items of consumers' durable goods, and steady climb of building materials, especially lumber.

To these statistics and opinions of others we might add our own comments as to the benefits of high production. Goods and services are the only tangible forms of wealth. Money is only a symbol of wealth and these symbols are very fickle. Not many years ago gold was the apple of one's eye. But see how many countries have gone off the gold standard. And in several countries silver is the favored monetary metal. The world is ever floundering around for other monetary symbols—uranium being one of the latest suggestions.

Recall what we quoted in our July issue from E. M. Voorhees, chairman of finance, U. S. Steel: "The enormous pile of paper claims—hand money, bank deposits, government bonds, etc.—is not a criterion of prosperity, for that pile was accumulated in creating goods and services that were destroyed during battle."

It is actual goods that are wealth. The manure pile in the front yard of the French peasant is of infinitely more value than many of France's bonds in recent years. When international or national financing gets

too confused, barter always saves the day—barter of one type of goods or services for another. There was considerable amusement when shortly before World War II the Germans sent thousands of harmonicas into South America. Smile, if you like, but harmonicas bought goods in return which German marks could not have done.

So, a large stock of goods in the United States is our best security in troubled times—with such stocks, times will no longer be troubled. Large production of those goods is the key to real prosperity.

Big Business Expounds on Labor

When the textbooks of the future on economics are written for the school and college boys and girls several chapters, as usual, will be devoted to labor-management relations. Much space will be given to the period of labor unrest immediately following World War II. Prominent in the exposition will be the long strike at the Westinghouse Electric Corp.

We already know much that will go into those books from a talk by Gwilym A. Price, Westinghouse president, who took several trade magazine editors behind the scenes in a 9-page dissertation at a recent luncheon. His subject was: "Management's Right to Manage". Here is one of the largest corporations—and its experiences may be regarded as typical. We will pick out some of his statements at random.

"Unions represent large masses of people, with power invested in an elected few. Therefore, it is vital, we think, that unions must be genuinely democratic institutions led by wise leaders. At our East Pittsburgh plant at a meeting for the election of union committee chairmen only 275 out of 17,000 voting members were present to cast ballots. At the last Presidential election the American people were chided because a mere 50% had gone to the polls. But here is a case where only 1½% voted at an important election.

"But management can do nothing because of the stringent restriction of the Wagner Act. It is up to the unions themselves to make their organizations working examples of democracy and wise leadership.

"During the strike we were accused of attempting to 'bust' the union. The company's attitude toward its employees is based on three principles: A right to employment regardless of affiliation with any religious, fraternal, labor, political or social organization; recognition of the right of the employee to determine the form of representation he considers advisable; a desire and interest on the part of management for the opportunity to discuss subjects of collective bargaining with authorized employee representatives.

"My main love is metallurgy—that's all that matters—I don't care whether you pay me 400 or 800 a week!"

"Unions serve a needed function as a bargaining unit, a collective spokesman, which can express the united wishes of the great mass of workers. Unions serve in other ways. They make it necessary for management's policies to be more stable and more adequately defined and more consistent throughout the company's plants in different cities. Unions can help solve minor grievances in their early stages and prevent their becoming major problems.

"Though quantitative figures are not yet available for the situation two months after the strikes' end, various managers say that productivity has increased. There is noticeable improvement in the attitude of workers toward their jobs. Absenteeism is less and quality of work is better since the number of rejects during inspection has dropped significantly. Employees usually show greater willingness to work.

"Our employees will continue to receive the best wages in the electrical manufacturing industry. The right to manage remains in management's hands. Relationships between management, the union and employees has been clarified to the benefit of all. The gains more than justify the long and bitter struggle."

One of the War's Great Men

Many interesting personages did we meet during the war, such as two Presidents, Henry J. Kaiser and Leon Henderson. One of the most intriguing of all was the "copper man" whom we encountered at Wright Field, Dayton, Ohio. A rugged fellow, he—who had doubtless eaten spinach, abstained from nicotine and alcohol, and seen his dentist twice a year.

This ingenious mechanical man, in which the human temperature was reproduced under a wide variety of unusual conditions, simulating those encountered by airmen, contributed much scientific information on how to keep human beings warm. The copper-covered robot has "skin" 1/16-in. thick in which the varying temperatures of different parts of the human body are duplicated. "Copernicus," as we like to call him, was chiefly instrumental in development of electrically-heated flying suits. There was said to have been considerable rivalry between Copernicus and human guinea pigs whom we saw through peepholes in the chamber where inside air had been rarified and brought down to perhaps minus 50 F.

We had almost forgotten the copper man until we read in the *General Electric Review* that he has been "reconverted" and is now playing an important peace-time role.

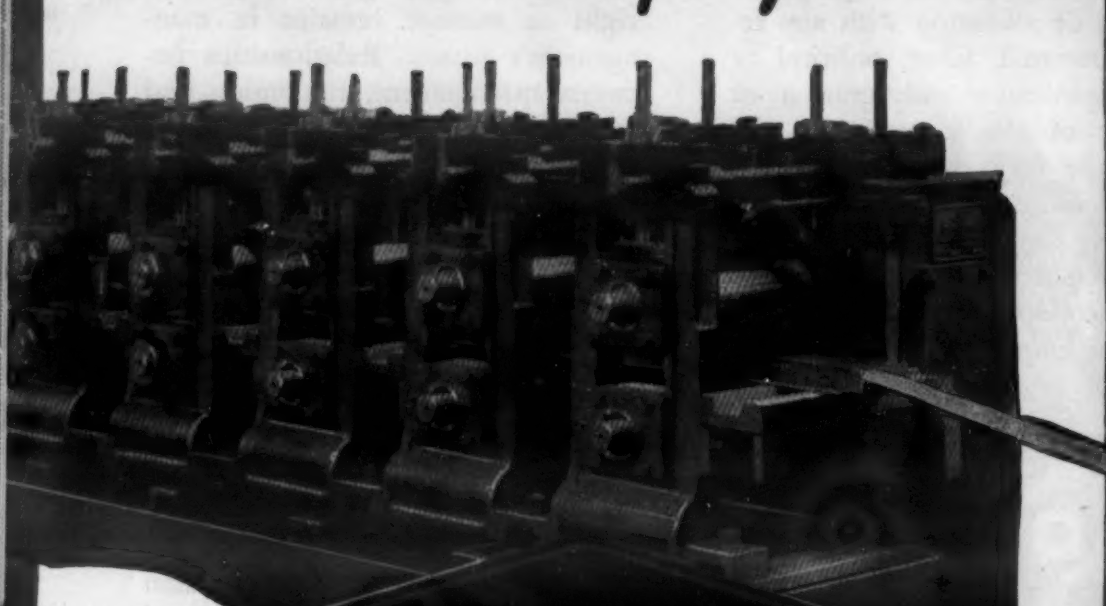
Somehow this copper man has gripped us, intrigued us—perhaps thrown his evil eye upon us unawares and has us under his spell. We want to write poetry about him—we're that bad off. We can start off, but somehow the poem just won't "jell." Someplace among our readers there beats a romantic heart, buried among test tubes, slide rules, pyrometers and calipers, gifted with poetic verse and fantasy.

Who will finish this poem, apologies to Longfellow?

"Blessings on thee, copper man,
Barefoot boy, with cheeks of tan—"

For the best poem submitted, with possible eye to publication, we will award a silicon carbide bath sponge.

How we keep your machines running Longer



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Echoes of '42—Get Out the Scrap!

"Open-hearth furnaces are being taken off for lack of iron and steel scrap. This is at a time when we can ill afford any further interruption of steel production. We are asking industry through its executives to immediately institute a survey of all properties for sources of scrap and to arrange to immediately collect and move its scrap into material supply lines. Our program needs the support of your worthy publication. Please give this drive maximum publicity. Your full support will help to keep the mills continually and sufficiently supplied."

Such was a telegram received recently from J. D. Small, Administrator of Civilian Production Administration. It is all reminiscent of the scrap and salvage crisis of 1942-43.

Meanwhile, the American Iron & Steel Institute has sent out an appeal, stating that both production scrap and dormant scrap are needed. The latter includes obsolete machine tools, equipment, jigs, dies, fixtures, etc. The Institute urges that again, as in 1942, each steel-using company appoint a top executive, with authority to make decisions, to set up a salvage committee to speed the flow of scrap that is generated in the normal process of manufacturing, and make surveys for untapped sources of dormant scrap.

The scrap should be sorted and turned over to the company's regular scrap dealers, states the Institute. It is important to act now in view of the approach of winter when the scrap movement in the North is slowed by adverse weather. On Aug. 1 scrap inventories at steel mills were low and incoming shipments were 35 to 40% below requirements.

To which we might add some of our own comments. Mr. Small of CPA told us at mid-June: "We've got to bring battle scrap to this country from foreign war theaters even though the transport cost is greater than its value." He did not state who will finance such an uneconomical movement, though perhaps if OPA allows scrap to reach its normal price level, that will be taken care of.

Another reason for the scrap shortage may be hoarding on the part of dealers and other holders in anticipation of higher prices. Still another reason is the fact that less production scrap is being produced because of more economical practice at manufacturing plants. One automobile maker, for instance, welds together small pieces for a useful auto part, pieces that would formerly have been scrapped. Again, the tendency to make steel items lighter in weight causes less relative scrap tonnage to be produced. Finally, we combed out so much accumulated scrap in the 1942-43 campaign that not much remains—such as abandoned railroad and trolley tracks.

Girlie Leaves the Steel Plant

You and I who visited plants during the war were often impressed by the large percentage of women performing men's jobs. When the industrial history of World War II is written, a mighty big place and lots of credit will go to the fairer sex. True, they did not perform as spectacularly as did Balkan women, who rolled boulders down mountains upon the oncoming enemy, or as Russian women, who killed Germans with greatest of ease in the front lines with the men.

Nonetheless, American women's performance was just as important. Often, of course, she had too much lipstick on for serious plant work; her slacks were a bit too tight about the seat; and often she may have been too flirtatious. But the great majority were serious and efficient. Many had husbands, brothers and sweethearts where the guns were booming.

The above outburst has been provoked, or inspired, by an apparently remarkable young lady, Miss Helen Cooper, Gary, Ind., who worked for the American Bridge Co. and whose photo and "Farewell Letter of a Woman War Worker" appear in the July issue of *U. S. Steel News*. Listen to some of her outpourings, apparently straight from her heart.

"I have been with A. B. Co. for 3⅓ years. At first I lacked confidence in myself and my ability, for I was a girl in a man's environment —in a man's world, a steel plant. It was two gold stars in the family that led me into steel. Next week I will be back in my home again. These war plant years I wouldn't have missed for anything. Here I learned more than I ever could have learned in an office. I don't mean in just running a crane efficiently. I've learned about safety, machinery, power, electricity, being alert and on my toes, to control my nerves during an emergency. I've learned a lot about human nature and salesmanship (Red Cross, etc. solicitations).

"I've learned that if an individual shows interest in his work he can get ahead by his efforts, hard work, ingenuity and ability. I've learned to cooperate, and have developed a deeper insight in my fellow men. I have developed a sense of security, a feeling of pride in ability, knowing I had the trust and confidence of my fellow workers. I've learned that a smile and friendly greeting really start a day off right.

"Some of the things that I have helped build will be all over the world; perhaps monuments that will stand long after my life is ended. I shall miss the old timers and their stories 'way back when.'

"If I were to take a Gallup poll of our shops, I think the highest rating would be given the company's truthfulness and frankness. We get a straight answer from management. They don't beat about the bush. They even ask our opinion.

"I have written this letter to let you know how much I have appreciated the consideration, kindness and interest which the American Bridge Co. has shown me. I shall never cross a steel bridge that my heart won't beat a bit faster and perhaps a lump come in my throat."

Chit Chat Re This and That

A new and more stable monetary system could be based on uranium instead of gold, suggests Prof. Farrington Daniels, director, metallurgical laboratory, University of Chicago. Uranium is now perhaps the most valuable of all elements. A given quantity is equivalent to a definite number of kilowatt hours of energy.

A Norwegian farmer plows his field with a motor boat. Living on the Kils Fjord in Sunnmore, this son of the soil has a field close to the fjord's edge. He rigged up a system of cables and blocks, backs his motor boat up to the shore, hooks on and plows away. With a long cable and pulley at the far end of the field he has only to signal his "seagoing horse" (power) and another furrow is plowed in the opposite direction. He does not have to breathe dust, has no bunions on his feet, and greets his friends with the Norwegian equivalent of "Ship Ahoy."

News of

Engineers — Companies — Societies

Engineers

Dr. Henry H. Hausner, consulting engineer for electrical engineering, powder metallurgy and high frequency ceramics, was recently appointed research associate with New York University, research department.

George W. Kurachek, formerly foundry metallurgist, Wright Aeronautical Corp., is now assistant foundry superintendent, Castalloy Co., Inc., Cambridge 42, Mass.

Emil Kern has been made chief engineer, Allegheny Ludlum Steel Corp., with headquarters at Brackenridge, Pa. He was educated in Germany and came to the United States in 1926 as an exchange engineer, joining the Mesta Machine Co., staying until 1945. He was also chief mechanical engineer with Reynolds Metals Co.

Charles Tichy, plant manager of the extrusion plant at Louisville, Ky., of the Reynolds Metals Co., has taken charge of the Phoenix, Ariz., extrusion plant leased from the government. He has invented new methods in the extrusion industry. *William F. Hunt,* who served under Mr. Tichy as chief engineer at Louisville's extrusion plant, will have the same position at Phoenix.

Joseph N. Peters is new manager of the Carbide and Cast Alloy Div., Jessop Steel Co., where he will supervise production and sale of tools, dies and wear resistant parts made from sintered and hot-pressed carbides and cast nonferrous alloys. Previous experience has been with Callite Tungsten Products Corp., Allegheny-Ludlum Steel Corp. and the Universal Cyclops Corp.

R. W. Mason, Jr., formerly with the Lithium Co., Newark, N. J., has joined the Development and Research Div., International Nickel Co., Inc., with headquarters in the General Motors Bldg., Detroit, where he will serve as metallurgist and consultant. He spent four years in U. S. Ordnance, engaged in specification of materials for, and engineering of, tanks and automotive materiel.

Capt. Mark E. Sink has joined Peter Muller Munk, industrial designer of Pittsburgh, where he will be responsible for research, servicing and production.

Donald A. Patter has been made research and development engineer for Universal Castings Corp., Chicago. By education and training he is a metallurgical engineer, having been with E. C. Atkins Co. and Naval Research Laboratory. He has researched on special alloy steels and precision casting.

Brig.-Gen. Donald Armstrong, who has retired from the Army after 36 years service, has joined the American Standards Assn. For many years he has been prominent in Ordnance work at the Watertown arsenal, at Chicago, and at Aberdeen, Md.

William Rodder has been made director of engineering, Aetna-Standard Engineering Co., Youngstown, Ohio, having been chief engineer, being succeeded by *Perry Snyder,* formerly of Youngstown Sheet & Tube Co.

Companies

P. R. Mallory & Co., Inc., Indianapolis, has established a new plant at 8605 Livernois Ave., Detroit, now producing special resistance welding dies, electrodes and allied welding parts fabricated from Mallory alloys.

A new concern, *Stark Industrial Models,* has been opened at 95 Jane St., New York 14, to supply designers, engineers, architects, advertisers and manufacturers with all types of working or display models of machinery, industrial plants, layouts, etc. Using metal, wood and plastics, the company, headed by John C. Stark, works from blueprints to the closest tolerances in any scale.

The *American Smelting & Refining Co.* has consolidated the operations of its Lead Products Div. with those of its Federated Metals Div. Alfred P. Knapp, general manager, Lead Products Div., and president of its subsidiary, Andrews Lead Construction Corp., acquires the operations of this subsidiary, together with the manufacturing plant in Long Island City and the homogeneous bonding business of the Lead Products Div.

The *Corning Glass Co.* announces plans for a pilot plant at Corning, N. Y., the first of its kind in the glass industry, to facilitate manufacture of new products and develop new methods. The company recently acquired new manufacturing facilities in Canada and in West Virginia.

Aluminum Co. of America has applied to CPA for permission to erect a plant in Des Plaines, Ill., for the manufacture of aluminum die castings. This follows the announcement in June that the company will build a large rolling mill near Davenport, Iowa.

Cleveland-Tungsten, Inc., Cleveland, subsidiary of *Molybdenum Corp. of America,* has purchased the *General Tungsten Mfg. Co., Inc.,* Union City, N. J.

H. K. Porter Co., Inc., has bought the business of the *American Spiral Spring & Mfg. Co.,* Pittsburgh, to be operated as *American-Fort Pitt Spring Div., H. K. Porter Co., Inc.* Porter now operates seven plants, manufacturing for railroads, processing industries and oil production.

The *Hungerford Research Corp.* has been merged with the Hungerford Plastics Corp. and will continue under the latter name. Hence, operations at Murray Hill, N. J., will be expanded in mold design and manufacture, material compounding and contract molding.

Earl S. Patch and C. Robert Talmage have formed the firm of *Patch and Talmadge* to serve industrial companies in the field of powder metallurgy, with offices and laboratory at 4 South St., Stamford, Conn. Their consulting service will deal with research, applications, sales, management, materials, production and equipment. Both previously served with the Moraine Products Div., General Motors Corp.

Societies

The *Magnesia Insulation Manufacturers Assn.,* Washington, has started a new publication, "Mima News", aiming to make better contact between users and makers of the insulation . . . An *Engineering Societies Council of New York* has been formed, comprising delegates from engineering, scientific and technical societies, with H. C. R. Carlson, A.S.M.E., chairman.

Meetings and Expositions

AMERICAN CHEMICAL SOCIETY, AMERICAN INSTITUTE OF CHEMICAL ENGINEERS AND ELECTROCHEMICAL SOCIETY, joint meeting of annual symposium on modern metal protection. Cleveland, Ohio. Sept. 21, 1946.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, fall meeting. Boston, Mass. Sept. 30-Oct. 2, 1946.

ASSOCIATION OF IRON & STEEL ENGINEERS, Iron and Steel Exposition. Cleveland, Ohio. Oct. 1-4, 1946.

NATIONAL ELECTRONICS CONFERENCE AND EXHIBIT, Chicago, Ill. Oct. 3-5, 1946.

SOCIETY OF AUTOMOTIVE ENGINEERS, Aeronautic meeting and Aircraft Engineering Display. Los Angeles, Calif. Oct. 3-5, 1946.

SOCIETY OF AUTOMOTIVE ENGINEERS, national transportation and maintenance meeting. Chicago, Ill. Oct. 3-5, 1946.

AMERICAN SOCIETY OF TOOL ENGINEERS, semi-annual convention. Pittsburgh, Pa. Oct. 10-12, 1946.

ELECTROCHEMICAL SOCIETY, fall meeting. Toronto, Canada. Oct. 16-19, 1946.

AMERICAN SOCIETY OF BODY ENGINEERS, Detroit, Mich. Oct. 23-25, 1946.

PORCELAIN ENAMEL INSTITUTE, annual meeting. French Lick, Ind. Oct. 23-25, 1946.

AN EDITORIAL

Still the No. 1 Question: "How Much?"

During a war economics bows to logistics, and the cost of a material, for example, becomes secondary to its performance, availability, speed of manufacture, etc. But in peacetime (or even the current reasonable facsimile thereof) "how much?" quickly resumes its position as the most important question of the day.

Cost factors have always been decisive in engineering. In "materials engineering" — the selection and processing of engineering materials — the price and supply of each material profoundly influence the extent of its general use as well as its suitability for a given application. Thus, other materials may be individually stronger or more machinable or more corrosion resistant, but plain carbon steel remains our basic raw material for manufactured products because it is simultaneously our most abundant and our cheapest engineering material.

Certainly the prices and supplies of engineering materials are just as important, directly or indirectly, in their selection and application as are their technical characteristics. Engineers and manufacturers who specify and buy engineering materials are as much interested in general trends in prices, supplies and market positions of these materials and in impending shifts among them as they are in improved fatigue properties, higher strength-weight ratios or new fabricating methods for them.

Accordingly, with the currently increasing importance of price factors in our field and the likelihood of broad changes in the "economic" appeal of certain materials in the months and years just ahead, your editors perceive a special opportunity and obligation for this magazine to analyze and interpret such developments for our readers, systematically, thoroughly and on a continuing basis. From now on, therefore, we will cover the economics of materials engineering just as intensively as we do its other and more technical aspects. Through the medium of feature articles and otherwise you will be kept informed on current and prospective fundamental price changes and supply factors that affect the applicability of individual types of metallic and nonmetallic materials, on fabricating and processing cost factors and on competitive situations that stem from primarily economic roots.

In the first article representative of this intensified editorial approach (starting on page 613 of this issue) Mr. Knight reviews the place of prices and other cost factors in materials engineering in general and makes interesting commentary on certain of the more obvious cost-competitive situations among materials. Later articles will discuss, one by one, such individual situations as those involving copper vs. aluminum for conductors, the price-economics of plastics and metals, magnesium's future position as a major metal, steel industry "extras," and many others.

These articles are designed to fill-in, as usefully and interestingly as possible, the economic background for the selection and processing of materials. We will need your help not only in providing data but in suggesting to us those materials-economics problems most worthy of study. So send us, please, your personal reactions to this program and your recommendations for likely topics to be treated in the future.

FRED P. PETERS

Editorial Comment

The Good and the Bad

It's not all-good, and it's not all-bad; it's usually somewhere in between. This sage maxim propounded by a swivel-chair philosopher can be applied to just about everything in the range of human experience, and certainly to the individual merits of all *materials* and all *methods*. Nevertheless, one finds everywhere and close at hand such airy generalities as: Steel is better than aluminum (or vice versa); a welded fabrication is more desirable (or less desirable) than a casting; infra-red radiant heating is better (or is worse) than convection heating.

Those who make such general statements do so either out of dishonesty or ignorance, for there is no material and no method that is the best or the worst for all purposes. Each and every engineering material and processing method has a specific set of properties or characteristics which clearly defines and limits its range of usefulness. Thus, in the long run, each material and method quite naturally concentrates in the field of applications for which it is best suited; and attempts to wander outside of this field of usefulness run head-on into unbeatable competition.

In selecting a material or method for a specific application it is also all-important to avoid general considerations and comparisons. Comparisons and the final selection should be based on analysis of specific facts about the materials and the methods involved One good reason why general comparisons should be avoided is that advantages and disadvantages of a material or a processing method very often vary from one application to another. In one case, certain of the characteristics will be advantages and others disadvantages; in another case, the nature of the application may reverse some or all of them.

The line-up of advantages and disadvantages will depend upon the particular conditions and circumstances involved. For example, the property of low melting points of lead-tin alloys is an advantage in solder or electrical fuse applications; but in considering materials for furnace use, this characteristic becomes an obvious disadvantage that precludes their use.

Invariably in the final analysis there is one method and one material which has some unique characteristics that offer certain desired advantages for the application at hand, and this determines the selection.

—H.R.C.

If You Want Steel, Supply Scrap

There have been recent rumblings about the scarcity of scrap as one more problem for the steel producers to contend with. The situation has now passed the rumor stage and is a reality that is helping to maintain the steel scarcity. A recent report states that the number of idle open hearth furnaces jumped from 12 to 30 within a month. According to the American Iron & Steel Institute, receipts of scrap have fallen to approximately 40% of requirements. If this trend continues mill inventories of scrap will vanish within 4 to 6 weeks.

What can we do about it? The most obvious step is to make certain that scrap is returned to the mills as fast as possible and in the most usable condition.

While not an immediate answer to this problem, industry can adopt other practices which will have some effect upon the persisting steel shortages. Such moves as that of Chrysler Corp., which now welds together odd-shaped pieces of scrap steel to make certain parts, reduces the demand for sheet steel and helps to spread existing supplies.

Many people have already forgotten the value of conservation which supposedly was well taught during the war. For some time to come industry in general will be hampered by materials shortages not only in steel but also in lead, zinc and copper. Thus, it behooves us to expend all materials with conservation rather than returning to the profligate habits of the prewar days.

—T.C.D.

The Goose and the Auric Eggs

We heard two interesting anecdotes within the same week, both bearing on the subject of labor. One manufacturer is said to be flying his semi-finished parts to Haiti for rough finishing. Then the parts are flown back to the United States for precision finishing.

The second anecdote deals with a manufacturer of silver plated wear. A new process, called electro-silverpolishing, gives the final polish in the plating bath, the one department therefore doing both plating and polishing, eliminating the buffing department, which in former days had been a very important one.

We asked the silver manufacturer: "Hasn't electropolishing thrown many buffers out of employment?"

His reply: "Yes, but we could only get in recent years 60% of the necessary buffers, and what we did get were only 60% industrious by former standards."

We do not wish to try to preach sermons to labor—too many, perhaps, have already done that. We should merely like to analyze cause and effect and probable future. The flight of manufactured parts to Haiti, of course, takes several man-hours of work outside of the country and lessens employment here.

Moreover, it may be argued that elimination of the buffers would have taken place just the same, had buffers been plentiful and efficient. However, we believe that such instances have been multiplied a thousand times over in one way or another—so many instances that it indicates an abnormal trend.

The fable of "killing the goose that laid the golden egg" comes home today, we believe, by the greedy attitude of labor, coupled with lack of restraining attitude at Washington. We believe that organized labor is young and inexperienced and should have had a more curbing hand placed upon it.

We are afraid that the golden egg goose is already sick. We hope that the owner of the goose, labor, and the veterinary surgeon, Harry S. Truman, et al, can cure the goose before it is too late.

—H.A.K.

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MATERIALS & METHODS

THE METALWORKING INDUSTRIES' ENGINEERING MAGAZINE

It takes much more than the price per pound to compute the cost of a material.

Economics of the Engineering Materials—Basic Considerations

by HAROLD A. KNIGHT, *News Editor*, MATERIALS & METHODS

THE PROBLEM WHICH CONFRONTS many an engineer, be he design engineer, materials engineer, chief engineer, or operating executive, is: What is the most economical material for a given application today, and what will be for the next five to ten years? In many a line of mass production, such as automobiles, it is necessary to take a long range view for tooling-up alone may need a year or two. Current economic conditions alone, especially if they are in a fly-by-night status, cannot govern materials that are to be chosen.

The engineer must first consider the basic principles involving the economics of materials. Thus, those which were depleted sadly by the war, such as copper, lead and zinc, promise to rise higher in price and may be difficult to procure—the present status of copper and lead.

Presented here is the first in a series on economics of materials. Subsequent articles will deal with specific competitive materials.

Moreover, there are many materials that will remain doubtful as to supply availability and price reasonableness, even when labor and industrial conditions are normal again, as far as American supplies are concerned. Thus, in mercury we have only 3% left of our original reserves; in silver and lead we have but 16%; of gold we have 19%; of chromium, 20%; of vanadium, 25%; bauxite (pre-war grade) for aluminum, 25%; manganese and tungsten, 30%; zinc, 33%; copper, 30%. Only in magnesium and nitrogen do we have 100%; with bituminous coal and salt, 98%. Vital iron ore stands at 68%; with molybdenum at 92%.

This does not mean to imply that we cannot import materials in which we are short, as we have already imported tin, rubber, nickel and other commodities. Submarine and other modern warfare being what it is, it would be wise indeed to stock-pile foreign materials during peace, but of course it is even better to use materials that are native to us and not to depend on whims of foreign nations as to price or dangers and high costs of ocean transportation.

Another basic principle is that products of infant industries tend to cheapen as manufacturing processes are refined and mass consumption allows good profits on a narrow margin. Thus, magnesium sold at over

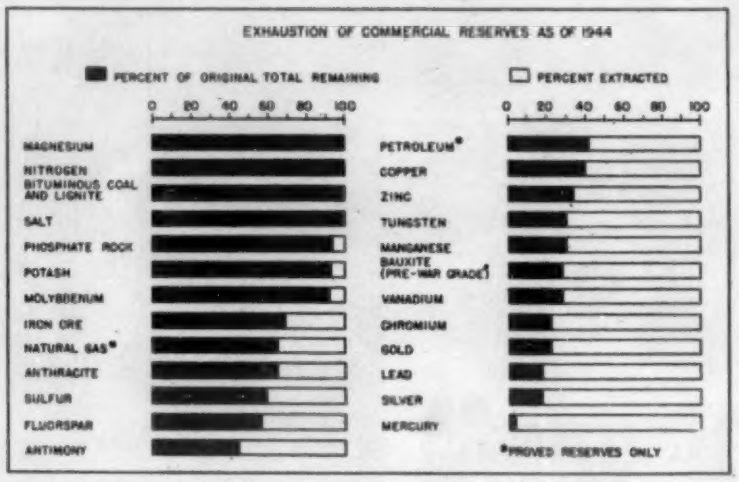


Fig. 1—United States reserves of minerals.

$5 per lb. in 1916 as against 20½c per lb. today. Classed in the infant industries are light metals, plastics, plywoods and modern glass.

One of the most pronounced trends is to make things light in weight. The world is extremely mobile today. Crossing the Atlantic was measured in months by Columbus; in hours today. Mobility implies lightness. Gone are the days when ponderosity meant strength. Strangely, in Germany, we saw the old and the new mingled—ponderous military tanks, automobiles and guns alongside magnesium and aluminum impedimenta of the infantryman.

In our country lightness of weight came into the machines and tools of industrial plants during the war when women entered the plants—they could not actuate the former heavy pedals and levers. Then, too, male workers found they were less tired at day's end because of lighter equipment.

So, we shall see lightness, as never before, an important adjunct of everyday life. Premiums will be paid, if need be, for such lightness for many products.

Another basic principle is that where competition is the keenest, the goods are apt to be the cheapest. Back in 1915 there was only one major source for aluminum. The Ford Motor Co. started to use aluminum hoods. Suddenly it was notified that the price of aluminum ingot was to be lifted from 18c to 30c per lb. Aluminum for hoods was straightway abandoned. Again, along in 1923 Ford used aluminum for doors in a 4-door sedan, only to have the price hiked. Only a little over a year ago, the Aluminum Co. of America controlled 86% of private aluminum manufacturing capacity, with Reynolds Metals Co. owning 14%. These figures have already changed, with Reynolds' capacity nearly half the nation's total and with Kaiser and perhaps others getting into the aluminum business. Besides, there is a tremendous government-owned capacity, much of which may pass into private hands.

Another basic principle is that a material which history has shown to have been fairly stable and reliable in price bids fair to continue in that direction. A ten-year price study of four other metals in the 10 years following World War I (Fig. 2) reveals how steady and sound has been the price history of steel. In the accompanying chart will be be seen how erratic copper, aluminum and lead have been by comparison with steel. Other considerations being equal, it would seem that the engineer could not go wrong with steel.

Other Factors, Too

There are other considerations, too, which though not basic, should be reviewed. A material which is most nearly pure in nature might be desirable over a lean material. With iron ore 55% metallic iron, it should be by reason cheaper than copper which is only 1 to 2% pure in nature. There are instances, too, where the high cost of the base material must not be considered, but consider rather that material in end use or at least semi-fabricated. Thus, silver at 75c to $1 per oz. cannot be compared with copper at 14½c per lb., but rather should be compared with the final cost of the brazed joint.

In fact, it is obvious that comparative costs of engineering materials is a most complex subject. It is difficult to lay down definite rules and formulas, as most cases are distinctly individual. Thus, a maker of desk telephones had used zinc die castings as bases. He now substitutes Tenite plastics, finding the second not only cheaper, but making a lighter product. Other plastics had proved either unsuitable, softening in warm climates, or too costly. In many applications, of course, zinc die castings are unquestionably the superior material.

This series of articles cannot begin to lay down set rules, slide rule calculations and nomographs which are accurate to the decimal point. It can only present principles, case histories and the best opinion of experts. This is truly a difficult period in which to estimate values and future trends—yet many engineers are faced with just such problems.

As Carl H. Burton, secretary, Aluminum Research Institute, once stated the problem: "Since the alloys of all metals are numerous (many of them highly specialized) about the only true yardstick for measuring costs comparatively is in the unalloyed ingot stage." To which he might have added "and with due consideration to their specific gravity." Thus, since magnesium is only a quarter as heavy as iron (1.80 specific gravity vs. 7.87 s.g.) it goes four times as far. One might divide the price of magnesium, 20.5c by 4, getting 5.125c, which actually compares with perhaps 4c for the grade of steel comparable with magnesium.

Performance—Cost Comparators

Several engineers have devised true price tables which have been weighted and packed with factors which must prevail in uses to which they must be put. Thus, J. R. Townsend, materials engineer, Bell Telephone Laboratories, has reduced four materials to a price basis, as of 1943, of cost per cubic foot, taking semi-fabricated rather than ingot materials. Thus, he priced aluminum at $25, copper at $85 (actually about $106 at today's prices); magnesium $22, and plastics $36 (but the price is probably lower now).

Elaborate, indeed, is the performance-cost com-

parator worked out for 20 engineering materials by Frederick Z. Pearson, manager, Plastics Div., Lyon Metal Products, Inc., Aurora, Ill. He adds weights to factors pertinent to the end use of his company's products. Though prices used are a year and a half old, his method may inspire other engineers to do likewise. In Fig. 3 the first three columns are obvious. In the third column—"manufacturing conversion factor"—the figures are arbitrary factors gained from experience or handbooks.

Included in this figure, for instance, might be the power requirements in machining which one expert says line up as follows: magnesium alloys, 1.0; aluminum alloys 1.8; yellow brass 2.3; cast iron 3.5; mild steel 6.3; nickel alloys 10.0.

It might be well for the engineer to compile for himself a table such as appears in Fig. 4 from the *Engineering File Facts* department of this magazine for February 1943, entitled "Comparisons of High Production Methods for Small Parts." (For more complete exposition, see the MATERIALS & METHODS Manual, No. 1, in the July 1944 issue consisting of several pages of costs and efficiencies of various metal forming processes, entitled "Selecting Production Methods for Small Parts." All of this data would figure in "manufacturing conversion factor.")

The heading for column 5 in the table, "Cost per 27.8 cu in." contains this rather odd figure since 27.8 cu. in. is the volume of 1 lb. of water of a specific gravity of 1. Figures in column 5 are arrived at by multiplying columns 2, 3 and 4. These give a comparable cost factor for all 20 materials. To get the cost per cu. in. one divides by 27.8, the cu. in. units being handy for calculating extra major properties of performance, like tensile strength, flexural strength, etc. in psi.

Through column 5 the table should be useful to all choosers of materials. Thereafter each designer can get up his own supplemental table, incorporating the special qualities he desires. According to column 5, stainless steel is so costly compared with other materials as to seem ridiculous as a practical material, on a cost basis alone. However, as to true costs where highest impact strength is required, combined with lowest water absorption, the quotient of columns 8 and 9 reveal stainless steel in the metals group and fiber-glass—low pressure laminate as outstanding materials.

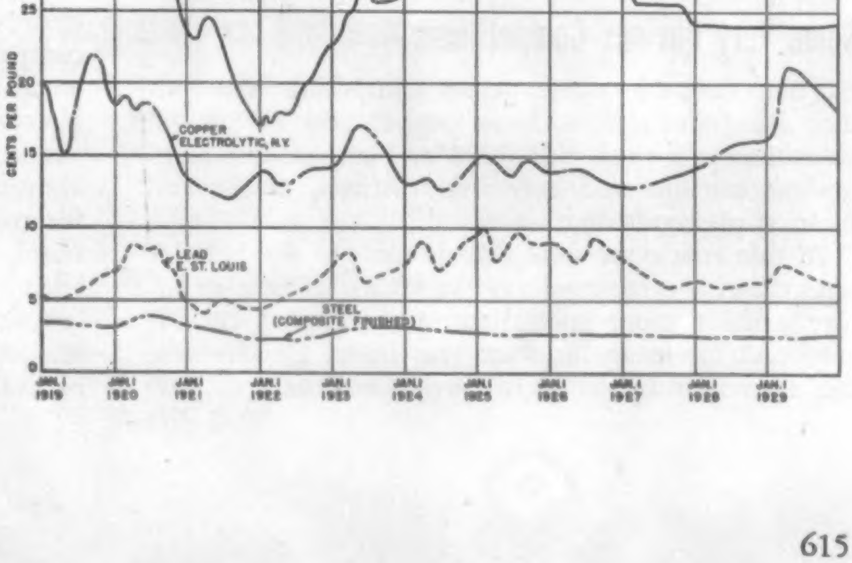
Considering no other requirements for the moment, the formula would be $\frac{\text{cost x water absorption}}{\text{impact}}$. For stainless steel this would be $\frac{840 \text{ (col. 5) x } 0.1 \text{ (col. 9)}}{25 \text{ (col. 8)}}$ $= 33\frac{1}{3}$. For fiber-glass take $\frac{370 \times 0.4}{15} = 10$. This would indicate a higher efficiency for stainless on the basis of impact resistance and water absorption alone.

In interpreting these figures, costs and water absorption should be minima, the author points out, and other performance data should be maxima for the most desirable material. That one showing the highest quotient of performance over cost should be the proper one to use in an application under consideration, provided proper emphasis is given to the one or two salient characteristics required for the proper functioning of this part.

Mr. Pearson also points out that certain factors, such as flexural strength, are not in direct relationship with costs. Thus, one can use twice the wall thickness for the same ultimate product cost when employing a material that is half the cost of the next one per cu. in. Now, if one makes a beam supported on two ends in the low cost material, twice the height of the one in the higher priced material, it is obvious that the flexural strength of this beam has not been doubled but quadrupled, since flexural strength increases with the square of the height of a beam.

The user of such a formula must use his own judgment as to importance of individual factors. Wishing to give special emphasis to some factor he may square all figures in that column for his cost performance formula. The author concludes that this method is a "reduction to mathematics of the product designer's common sense."

It is well for the engineer to have handy tables comparing certain key properties of competing materials for ready reference. Thus, Mr. Townsend of



Over a period of 10 years steel showed the least price fluctuation.

Fig. 3—Performance-Cost Comparator for Materials

Material	Cost (¢) Per Lb.	Specific Gravity	Mfg. Conversion Factor	Cost Per 27.8 Cu. In.	Flexural Str. (10^{-3})	Modulus of Elasticity (10^{-6})	Impact Str. Ft.-Lb. per In./Notch	Water Absorption in 24 Hr. (%)	Resistance to Continuous Heat	Surface Hardness (Rockwell M Scale)	Dielectric Str. (V/Mil-⅛-In. Thick)
Steel Sheet, Deep Drawn, Paint Finish	3	7.80	3	70	80	29.00	29	3.0	500	1200	*
Aluminum Sheet, Deep Drawn, Finished	20	2.80	2.5	141	40	10.50	20	1.0	500	108	*
Magnesium—Cast—Finished	27	1.80	3	144	30	6.50	20	2.0	500	100	*
Stainless Steel—Deep Drawn	36	7.80	3	840	120	28.00	25	0.1	600	120	*
Masonite Hardboard, Synthetic Enamel	5	1.18	4	23.6	12	0.70	3	10.0	230	80	125
Plywood-Mahogany—Lacquered	7	0.80	4	22.2	19.3	1.64	4	10.0	180	80	50
Plywood—Urea-Impregnated	9	0.80	4	28.6	19	1.50	4	5.0	230	95	100
Compreg—Phenol-Impregnated	12	1.40	4	67	36	3.60	6	7.0	230	95	115
Grade X-Laminated—Paper Base	11	1.35	2	29.6	16.5	1.70	2.5	4.6	230	95	700
Grade C-Laminated—Cloth Base	25	1.35	2	67	15	0.90	15	5.6	230	95	375
Creped Paper Base-Phenolics	30	1.40	1.5	63	17.5	1.70	1.5	4.6	230	95	650
Creped Cloth Base-Phenolics	60	1.40	1.5	126	16.5	0.90	6	4.6	230	95	375
Cloth Base—No Pressure Resin	35	1.40	1.6	78	20	1.00	15	1.8	230	95	300
Glass Base—No Pressure Resin	135	1.70	1.6	370	33	1.90	15	0.4	480	108	550
Grade C Laminate—Post-Formed	60	1.40	1.5	125	20	0.90	15	4.6	230	95	375
Cord-Filled Phenol Molding Compound	30	1.40	1.7	72	12.5	2.00	7.2	1.4	230	98	300
Sisal-Phenolic Laminate	40	1.35	2	107	20	0.50	12	8.0	230	95	350
Vinylidene Chloride	40	1.73	1.5	104	16	0.35	6	0.1	180	57.5	350
Polystyrene—Molding Material	25	1.06	1.5	40	13.5	0.35	0.4	0.1	170	82.5	600
Cellulose Acetate-Butyrate	35	1.30	1.5	59	10	0.35	8	2.0	180	48	325

** Conductor*

Courtesy: Frederick Z. Pearson, Lyon Metal Products, Inc.

Bell has several such tables. One is a triple table showing in the first column specific gravity, ranging in his table from 11.34 for lead down to 0.63 for wood; in the second column are listings of tensile strengths, ranging from 189,000 psi. for alloy steel down to 200 for concrete; the third is modulus of elasticity, psi., ranging from alloy steel, 30×10^6 down to 2.7×10^5 for cellulose acetate.

Another table gives ratio of tensile strength to specific gravity, ranging from 43,860 for polyamide down to 90 for concrete. Still another compilation involves notched Izod impact, ½ in. x ½ in. bar, described in foot pounds and cost per lb. He lists other considerations, with an eye towards plastics, consisting of the following: Transparency, crazing, cracking at inserts, unmolding (warping and stress release), resistance to common solvents, resistance to light and humidity, fungus growth, welding characteristics, moisture content at time of molding, control of molding temperature and pressure, supply of raw material and defense restrictions.

Some Very Obvious Competitions

There are, of course, many competing materials that are "naturals," such as copper and aluminum, aluminum and steel, aluminum and magnesium, magnesium castings and gray iron castings, metals and plastics, plywoods and plastics.

In this article we shall discuss some of the broader aspects, with occasional case histories, leaving to future articles more specialized and detailed considerations. There are at least two broad trends—one the ascendant tendency of newer materials to partially supplant the older materials; and the increasing importance of the light materials over the heavy and more cumbersome older materials.

Perhaps the first thing that comes to mind is the inroad made by aluminum in the copper market, an ironical development being the stringing of high tension aluminum lines through Montana, the leading copper producing state.

As a consulting engineer stated to us recently: "Copper lost the field of high voltage electrical transmission long ago to aluminum. Not so recently it surrendered the medium high voltage field in electrical conductors. Competition on bus bars remained, but that passes out of the picture. Now on a purely price basis, apart from other engineering considerations, the last phase is that of wire, braided, and insulated conductors and the vast field where copper was thought to be supreme and without competitors." When this statement was made copper sold at 12c; aluminum at 14 to 15c. Since then copper has risen to 14½c.

With copper and aluminum at virtually the same price, a new era has arrived. Note Fig. 2 and price comparisons ten years after War I. Only in 1922 were the two close together, but with aluminum always dearer. But, of course, aluminum has an advantage on a volume basis. Thus, a cubic inch of aluminum weighs but 0.0975 lb. as against 0.3217 lb. for copper. Copper, of course, is favorable from the standpoint of having a lower specific electrical resistivity, standing at 1.682 micro-ohms-cm. vs. 2.655 for aluminum; but a lower weight (and therefore less material cost) of aluminum is required for equivalent current-carrying ability, hence aluminum

Fig. 4—Suggested Table for Figuring Costs

Characteristics Compared		Zinc Alloy Die Castings	Gray Iron Sand Castings	Steel Stampings	Steel Screw Machine Parts	Molded Plastics Parts
Relative Cost and Production Features	Production speed	2	5	1	4	3
	Machining cost after casting	1	3	—	—	2
	Tooling cost	4	2	5	1	3
	Cost of applied finish	2	3	1	2	1
	Cost of materials per lb.	3	1	2	2	4
	Scrap loss	1	2	3	4	1

has the ultimate economic advantage.

In favor of copper for electrical transmission is its ease of handling. Thus, it is easy to splice the pliable copper wire. To fasten aluminum one must usually use patented connections. By tradition and experience copper is the easily handled material. However, much work done with aluminum during the war has added greatly to the technique of the average worker with metals.

Magnesium: Up and Coming Material

One of the most glamorous metals of today is, of course, magnesium which in theory, at least, has the most promising future of all materials, if for no other reason than its abundance. It has been stated by imaginative light metal engineers that had the magnesium industry been set up as we now know it, before iron and steel had been developed, the ferrous industry would have found it difficult to become established and forge ahead. What ponderous machinery it takes to smelt, refine and work steel! What a corrodible metal steel is! How hard to machine! It forms scale even in process of manufacture. It must be painted constantly, else its life in years is counted on the fingers of a hand.

For its raw materials (sea water, Michigan brines and dolomites) the magnesium supply is unlimited. It is one-sixth the most abundant material. There are several who boldly prophesy that it has a greater future than aluminum. The sales manager of Dow states that within the next two years the price will go down from the present 20½c per lb., not so much because of quantity production as because of technological advances. He says that the metal could be reduced by as much as 25% over the next five years. A key expense is electric power, which costs about 1.58c per lb. of magnesium, as against 0.5 to 3.5c per lb. for aluminum.

Power tends to become cheaper after a producer has been long in business and amortized the original cost of his dam, power house and transmission lines. Thus, the power cost of Aluminum Co. of America is said to be only ½c per lb. of metal as against 3½c for Reynolds, because the former owns its facilities and has completely paid for them whereas Reynolds buys power from the Government-owned TVA. But even the government power projects will eventually be paid for and its rates should decline.

Moreover some power companies sell "secondary" power which is the water that would go over the dam in the spring and during winter thaws and would otherwise be wasted. A magnesium or aluminum producer could average down his cost of production by using this "secondary" power some of the time.

Magnesium and Aluminum

Magnesium and aluminum are in many respects sister metals. An aircraft manufacturer found that in producing an aluminum stabilizer, costs were $231 ($40 for material and $191 for labor) vs. $140 for magnesium ($62 material and $78 for labor). The Douglas Aircraft Co. states that a finished magnesium I-beam is 25% cheaper, 35% stronger, and 5% lighter than the aluminum beam it replaced. As to magnesium die castings, one manufacturer lists machining costs as 25% higher for aluminum, 35% higher for bronze and 50% higher for cast iron than for magnesium.

An interesting case history is that related by Edward S. Christiansen, president, Magnesium Assn. He said: "We have found certain aluminum castings where we can cut the section to ⅓- or ½-in. thickness with magnesium stampings. Also with the lower specific gravity of 'mag' we come up with 30% of the weight of the original aluminum castings. That gives us enough edge in price to compete. We received a good order for a cover for an adding machine case that was originally designed in ⅛-in. thick aluminum. We ended up with 0.051-in. magnesium. We might have used 0.040-in. thick magnesium but they objected to such thin material."

Magnesium vs. Cast Iron

It may be a surprise that magnesium is competing in several instances with gray iron castings. As one engineer expresses it, "Compared with pig iron, magnesium is way out of line, but the saving grace is the exceptional physical properties of magnesium and the fact that fabricated cast iron parts are invariably over-designed and excessively heavy. Moreover, with magnesium, the user can decrease materially his handling costs—raw material entering the plant, material in process in the plant and shipments of finished goods."

Magnesium is supplanting gray iron in certain working parts of lawn mowers—not merely serving as housings. Thus, magnesium gears substitute for iron. One manufacturer of such parts says: "We have the answer to the corrosion, wear and impact question. We put iron and magnesium castings into an acid bath for 72 hr. Iron was badly deteriorated; magnesium only partially so. He goes on to say that manufacturers were buying gray iron castings at 6c per lb. before the war—today they are 15 to 20c per lb. Magnesium has supplanted gray iron with a maker of X-ray equipment. In both cases mentioned the users say they will not revert to cast iron.

Another interesting competition, not generally known, is between galvanized steel and secondary, or scrap, aluminum for roofing. The movement bears watching. As the price situation lined up early this year the consumer paid $10.50 to $12.75 per 100 sq. ft. for aluminum roofing against $6.50 for galvanized steel. However, the latter has been unprofitable for the steel mills and higher prices seem probable. Here is a material with virtually indefinite life (aluminum) compared with a material lasting no more than a generation with good care. Handicaps of the aluminum roofing are: It takes twice as much lumber for the roof deck on which the metal is laid; it is difficult to lay because of expansion and nailing problems. Again, aluminum sheets may prove to be brittle.

Glamor Material: Plastics

The chief complaint about plastics as a competitive material are their high cost, but here the price tendency continues downward after already drastic declines. Thus, polystyrene sold at 45c per lb. in 1942 and reached 25c in 1944. It may drop further to 20 or even 15c. It is pointed out that a pound of plastic will go considerably farther than a pound of glass, copper, aluminum or even magnesium. Herbert R. Simonds, author of the forthcoming book, "The Plastics Business," states: "Plastics prices as a whole are still quite high in comparison with other basic materials." Some time ago the magazine *Plastics World* listed how many cubic inches of various plastics a crisp one dollar bill will buy: thermosetting group—general purpose phenolic, 150; urea, 48; melamine, 45; thermoplastics group—polystyrene, 90; cellulose 47; cellulose butyrate, 46; polyvinyl, 43; ethyl cellulose, 40; polyethylene, 40; acrylic, 29 and nylon, 15.

As to good old steel, we have already mentioned (Fig. 2) how steady, moderately priced and sedate steel prices have been all these years, compared with other metals. Usually for comparative purposes it is called 2½ to 3c per lb. Even after the $5 per ton rise early this year prices of steel were only 5% over the 1937 level. Over the same period hourly wages went up 70%. If steel prices had been brought into line with other commodity prices the recent rise would have been $19 per ton instead of $5. The composite price of finished steel since January 1941 rose 14% against 33% for the index of wholesale prices. "Steel Is Still King," as was stated in the headline of a recent editorial in MATERIALS & METHODS.

The trouble is with most cases of choices of engineering materials, it is difficult to prove their cheapness, all things being considered. It was a rare case, therefore, when Henry J. Kaiser proved conclusively the advantages of magnesium truck bodies. At his Permanente, Calif. magnesium plant he used trucks in which all body parts were made of "mag," including hoppers, hatches, covers, handles, hubs and spokes of gears. Construction was Heliarc welded and riveted magnesium sheets rolled by Revere from Permanente magnesium. The trucks cost $3,750 against $1,750 made of steel. The pair of trucks used in hauling magnesium oxide thus cost $4,000 in excess of steel trucks. But they made three round trips daily, carrying 4 tons of oxide more than would steel trucks, a net saving of $31.20. In 128 days the $4000 was offset and thereafter Kaiser made money because of the extra 4 tons per load.

The ascendancy of one material over another does not necessarily work harm on the overtaken metal The history of our country shows that discoveries or developments of new materials and processes increase total industry and prosperity and carry along the older materials in the wave of prosperity.

The older materials will not suffer from the newer ones. There are continual improvements in the old. Fifteen years ago it was deemed impossible to deep draw steel into present day automobile bodies and fenders, thin, smooth and tough. With growing radar applications, for instance, copper will find new outlets to make up for lost markets. As a compact electrical conductor it has no peer. Magnesium and aluminum have a brilliant future, with perhaps magnesium developing the most rapidly for it is now farther back. There are some truly wonderful plastics which bear watching and which will cheapen from present high prices: Nylon, Silicones, Teflon and Vinylite. (Silicone varnishes cost $15 a gal.—seven to ten times the cost of other good varnishes.)

The present era is not a proper one in which to make final judgment on values because of too many uncertainties in government, politics and sentiment of the people. The old line automobile makers, realizing that it takes two to three years between the original design and first production, are usually playing safe by adhering to previous materials. Bolder makers, like Crosley, are using innovations—Crosley is using an all-aluminum body on his midget car.

But when conditions become more settled, supplies of materials more abundant and prices reach more typical or representative levels, one can look for a field day of shifting to different materials, with many novel uses.

Despite uncertainties the clever materials man will be studying the economics of materials, now, and will have immediate answers if the boss approaches him today for an item for tomorrow.

In future articles we'll try to get down to more specialization—to detailed discussions of individual competitive or economics situations in each article. Slated for future attention are copper vs. aluminum, plastics vs. metals, "extras" on steel, etc. Watch for them!

Added engine life is expected from a new system of cylinder bore finishing which leaves bore surfaces criss-crossed with minute grooves.

Machining and Finishing Cylinder Bores at Buick

by KENNETH ROSE, *Engineering Editor*, MATERIALS & METHODS

THE FINISHING OF CYLINDER BORES has an important bearing upon automotive engine life and performance. Several methods of finishing are in use, and each has its group of proponents. At Buick Div., General Motors Corp., a method of machining and treating cylinder bores has been developed by research, and is now in use in the engine plant.

The method provides for (1) the use of machining operations that create a minutely grooved surface; (2) a honing or lapping process to smooth this surface partially, and (3) a chemical treatment to create a surface texture that will promote proper lubrication during the early life of the car. Several interesting tools and inspection devices have been developed for the process.

Operations upon the cylinder bores begin with the opening of the cored hole in the casting. This is done in a rough boring procedure, using 6-bladed cutters. For these cutters J-metal, a Stellite-type cutting tool material, has shown itself to be satisfactory.

The motor block casting is intended for a straight-eight motor, and the boring is done on an 8-spindle machine to get high production. About 3/16 in. of stock is removed in this first operation, which required about 50 sec. actual machining time. The cylinder bore is 9 3/16-in. long.

The next operation performs the functions of a finish boring, but as it also corrects any misalignment of the cylinder bores it is referred to as straightening. About 0.035 in. of stock is removed. Time for this operation is the same as for rough boring, that is, about 50 sec.

In the actual creation of the surface pattern, the diamond boring that follows the straightening is one of the most important operations. While the boring was formerly done with diamond tools, Carboloy-tipped cutters are now used. The work is done on an Ex-cell-o 8-spindle vertical boring machine, equipped with hydraulic clamping and controls. With the spindles revolving at 500 rpm. the machining time is about 26 sec.

As the purpose of the diamond boring is to form a pattern on the interior walls of the cylinder bores as well as to size the bores accurately, the operation is closely controlled. The feed per revolution is held at 0.006 to 0.008 in. The cutting tools are ground with 15 deg. clearance, 60 deg. lead angle, and 70 deg. back relief, and with a small but definite radius on the nose. This radius is ground to 0.015-in., and is held at the indicated curvature quite accurately.

As a result of the diamond boring the cylinder walls have had cut into them a very fine spiral groove, with a pitch of 0.006 to 0.008 in., and with a rounded trough, or root. This constitutes the first part of the surfacing procedure. The "threaded" effect created by the diamond boring is distinctly visible in the cylinder bore at this stage, although the total variation in the surface is less than a thousandth of an inch.

The honing operation is not intended as a sizing procedure. Its purpose is to smooth off the minute peaks left by the diamond boring, and to create a crisscross pattern of honing scratches in the cylinder bore. The surface will then consist of a honed cylindrical bore with the remains of a spiral groove cut into it, and with the crisscrossed honing marks the only surface variation clearly visible.

Honing is done in an 8-spindle Barnes machine, using Micromatic hone holders. A long, fast stroke is combined with a rotary motion to give the desired

The finished pattern inside the cylinder is completed within a few seconds on a multiple-spindle honing machine.

pattern. About 18 strokes are all that is required, and the whole process requires only a few seconds. As has been stated, honing is not used as a sizing procedure, but for pattern only.

The maximum roughness of the cylinder surface following the diamond boring operation is about 0.0005-in. Slightly less than this amount of metal is removed during the honing, as a small part of the trough remains after honing.

The stones used are of 150 grit, with J bond, as supplied by Micromatic Hone Co. Six stones are mounted in each holder.

Following the honing operation, the motor blocks are moved to a special Sheffield Precisionaire gage, where the eight cylinders are simultaneously examined. The gage indicates variations from a standard at four places in each of the eight cylinders, the 32 simultaneous readings indicated on the face of the instrument by bobs held in tubes by a current of air.

The instrument operates upon the air gage principle. Pistons are inserted, one in each cylinder, and each piston bears four plugs. The plugs are located at points corresponding to the skirt of the cylinder, the bottom of ring travel, a location in the ring travel, and the top of ring travel. Each plug contains several air ducts, and is connected to a tube on the face of the instrument. The amount of air passing through any of these orifices is a measure of the snugness of the fit of the cylinder around the plug at that place. This amount of air is in turn measured by its ability to float a tiny bob in a tube on the instrument panel, and the reading is made there.

Readings are made in steps of 0.0003 in., but are indicated as class of fit according to Buick practice. Thus, a cylinder of slightly large size might be a #9 fit, or 0.0003 in. larger than a #8. A hinged lever above each cylinder, and attached to the gage, bears

a revolving stamp that can be set to the class of fit indicated, and stamps this class number on the motor block near the cylinder. The stamped numbers are later referred to when selecting a piston for that cylinder at assembly.

The gaging pistons in the Precisionaire gage are rotatable, and a reading can be verified by giving the piston a quarter turn while in gaging position.

To bring the top and bottom readings together, the order of locating the tubes has been changed from the order of the plugs. The first tube gives the bottom reading, while the next gives the top reading. In this way the class of fit can be easily judged.

Conveyors for the motor blocks are of two types; racks with rollers are used at most of the machines, while chain belts with bar spacers are used for moving the blocks from one machine to the next. The racks are placed at the height of the machine tables, so that the blocks can be pushed from the rack directly onto the machine table. Chain belts are power-driven, and serve as conveyors for the longer distances from one part of the shop to another.

The machining of the cylinder bores is completed with the final honing for pattern, but another step is required to complete the processing of the cylinders. To assist in maintaining a film of oil over the cylinder walls, the interiors of the cylinders are given a chemical treatment known as the Lubrite treatment. The blocks are brought by conveyor to a circular processing system, or "merry-go-round," consisting of a slowly moving conveyor inside sheet steel drip and splash guards.

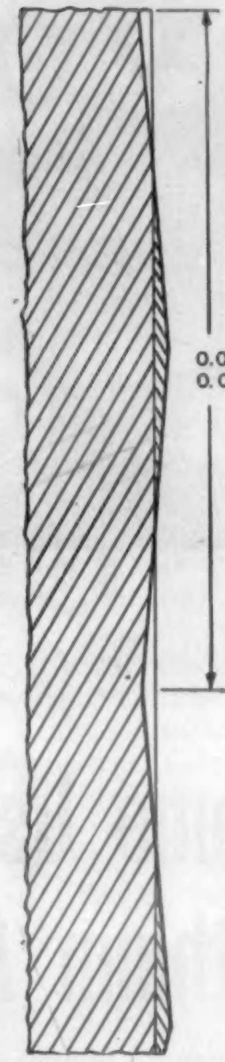
The blocks are moved onto the circular conveyor, the bottoms of the cylinders are sealed off, and hollow steel cylindrical tubes are placed inside the cylinder bores. These tubes, closed at the bottom, greatly reduce the amount of liquid needed to fill the bores. Hot Lubrite solution is then added to the cylinder bores until it fills the space between the cylinder walls and the hollow tube. The temperature of the solution is maintained at 205 to 210 F at all times.

Reaction between the solution, largely an acidified manganese carbonate, and the walls of the cylinder is rapid, and proceeds with a slight "gassing." Evolution of gas is not sufficient to cause spattering, and the steel guards around the motor block are placed more to catch drippings during the beginning and ending of the cycle than because of splashing during the process.

The entire treatment in the circular conveyor requires only a few minutes. After removal of the solution and drying of the cylinder walls a grayish residue remains. This is easily removed by wiping, and the walls then show a black, velvetlike surface.

The blocks are placed in another honing machine, similar to first in type but having cast iron sticks in the hone holders instead of stones. The cylinders are given six to eight strokes on this machine to smooth out any irregularities resulting from the chemical action. No metal is removed.

Processing of the cylinders is complete with this operation, and the blocks are moved to another department.



An exaggerated view of the cylinder wall after the diamond boring operation. The high portions are removed by honing.

Readings at 4 locations in each of the 8 cylinders are given simultaneously. This sketch shows one of the 8 sets of columns. Left to right the air gage shows readings at diameter of skirt, at top of ring travel, in ring travel, and, at bottom of ring travel.

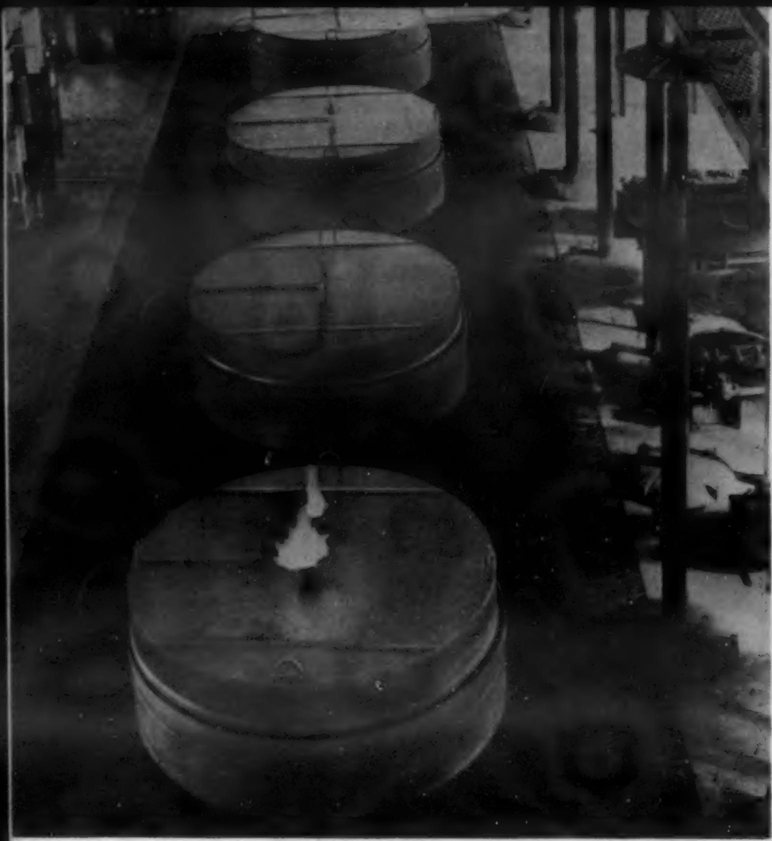


Fig. 1—Pit type stress relieving furnaces at the Tube Reducing Co. plant.

Several users of lithium protective furnace atmospheres report them a sure and economical way to prevent scaling and surface decarburization.

Some Users' Experience with Lithium Atmospheres for Heat Treating

by ROBERT S. BURPO, Jr., *Associate Editor,* MATERIALS & METHODS

MANY OF THE USES to which steel parts are put require physical properties that only are available after the material has been heat treated. For this reason, the heat treatment of steel parts (either to increase the hardness and wear-resistance, strength, or toughness) is a very important industrial process. It is also a process that requires very accurate control if the parts are to be both uniform and clean after treatment. These two problems of cleanliness and uniformity of hardness (or of other properties) can be obviated if the heat treated parts are free from scale and if both carburization and decarburization of the work-pieces can be accurately controlled.

Prior to considering the means for the control of carburization and decarburization, let us think of what happens when a piece of steel is heated in a furnace. The work-piece absorbs heat with little or no change in appearance or composition until it becomes red hot (at about 1100 F). Then, as its temperature increases, scale appears on the surface of the steel. This scaling is the result of the interaction of several compounds (or elements) in the heated air inside the furnace with the hot steel. Scale on a piece of hot steel prevents it from cooling uniformly in the quenching medium, hence it will have soft areas on its surface. And if a piece of steel has scale on its surface, it has been exposed to a harmful atmosphere. Therefore, scale not only prevents uniform hardening, but it indicates that the surface of the work-piece has been attacked by a corrosive (usually oxidizing) atmosphere.

. Hardened parts that contain soft spots often are useless and are therefore rejected. It costs money to remove scale. These are reasons why scale must be prevented from forming.

Just as scale causes increases in production costs and in rejections, decarburization is likewise uneconomical. Decarburized steel is iron, and iron will not harden nor will it resist wear. Often scaling and decarburization occur together or successively. The decarburization is caused by some component of the furnace atmosphere "enticing" the carbon in the steel to leave; when the carbon is extracted from steel only iron remains.

Considerable has been written about those compounds or elements in furnace atmospheres that cause decarburization and/or scaling. Hydrogen, oxygen, water vapor and carbon dioxide, and various mixtures of these have been blamed. Of course, if one could heat steel parts in a vacuum (which isn't commercially feasible) or in an atmosphere devoid of these

harmful agents, the problem might be solved.

Controlled Atmospheres

Controlled atmospheres have been the answer to the problem of eliminating scale during heat treatment. Many atmospheres on the market have a limited range of usefulness; one type of gas is used for carburizing, another for neutral hardening, a third for bright annealing and/or brazing, and yet another for carbon restoration processes.

Many of these atmospheres cannot prevent decarburizing without causing carburization. It has been found that some neutral atmospheres allow the production of clean, scale-free, but decarburized work. In general, controlled atmospheres require extremely accurate control (by gas analysis methods) if they are to perform the desired job. This means that a constantly varying control is needed to balance the scale inhibitors (which are also decarburizing agents) with the proper amount of carburizing gases so that the work-pieces are neither subject to scale nor to decarb. The balance between these components is critical. If carbon restoration is desired, a new complication is added, for in some cases, excessive carburization can be as detrimental as decarburization.

From the experiences of the users of lithium atmospheres, it would seem that one answer to this important industrial problem has been furnished by the Lithium Corp. of Newark, N. J. (the manufacturers of lithium atmosphere furnaces). This atmosphere, according to the user-data obtained during the preparation of this report, will prevent scaling (or oxidation) and will control both carburizing and decarburizing. By the use of this one heat treating atmosphere, according to the reports, decarburized steel work-pieces can have the missing carbon restored (to its former value), low carbon steels can be carburized to any carbon concentration desired (without a soaking or diffusion period), and steels can be hardened with no scaling or decarburization.

All of these things cannot be accomplished at the same time, however. By simply adjusting the ratio of the air-gas mixture introduced into the furnace, the atmosphere can be changed from a carburizing medium to one suitable for neutral hardening. Likewise, for carbon restoration, only a resetting of the air-gas mixing valve is needed to correct for carbon losses in steels of varying carbon content.

Briefly, the principle of this multipurpose atmosphere which can perform several different jobs is illustrated by the schematic diagram, Fig. 2.

The correct air and propane mixture is cracked in a gas heated cracking unit. This produces a hydrocarbon gas that can, when properly controlled, create a carburizing atmosphere in the furnace. This cracked gas is run through a water cooled (ordinary water from the city mains is adequate) cooler which removes some of the moisture. No attempt is made to really dry the cracked gas, as this has been found unnecessary. Following its passage through the cooler, the cracked gas goes to the "lithium generator." This is a small chamber heated to a temperature between 1200 and 1500 F which contains (usually) two "lithium cartridges."

A sheet steel cup approximately 3 in. in dia. and 4 in. deep containing a mixture of lithium salts (lithium chloride and carbonate mixed with a small amount of metallic lithium) is the "lithium cartridge." When heated, these salts vaporize. Lithium vapor is picked up by the cracked propane gas as it flows through the generator, and the resulting mixture is the versatile atmosphere whose uses can be determined by changing a manually operated valve setting as a control.

The furnaces are conventional, it is only the atmosphere that is notable. While any type of furnace can be used satisfactorily with a lithium atmosphere, only gas fired muffle and radiant tube types have been promoted, as they seem to be the most economical. To date, batch type (box and pit) and continuous furnaces have been built and operated successfully. Some examples of these various types of furnaces are described below.

Particular Furnace Types

Several different examples of lithium furnaces will be described as they illustrate the capabilities of lithium atmospheres when applied to the solution of heat treating problems.

A general purpose lithium installation can be found at the plant of Waterbury Farrel Foundry & Machine Co., Waterbury, Conn. This company makes cold heading and thread rolling equipment, nonferrous wire drawing machinery, presses, rolling mills, and draw benches. Many parts of these machines must be carburized and/or hardened. A box type lithium furnace is used to heat treat these parts to very close hardness tolerances.

Installed in 1942, the furnace was used exclusively for neutral hardening until early in 1945. Since then it has been refitted and is now used for carburizing during the night and for hardening during the day. This changeover from carburizing to hardening, and vice versa, is accomplished by throwing a switch on the control panel and then resetting the temperature control.

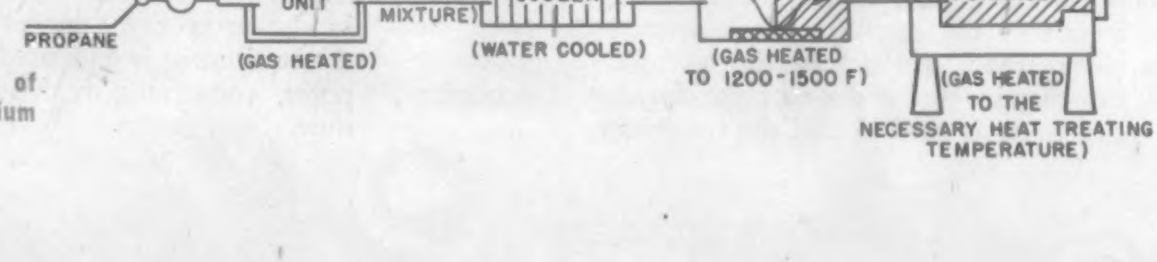


Fig. 2—Schematic diagram of the flow of gasses in a lithium furnace.

Fig. 3—These three travelling carbon restoration furnaces are used in conjunction with 500-ton forming presses to make hollow steel propeller blades at Hamilton Standard Propeller Div.

When used for carburizing, the furnace temperature is set at 1700 F and no soaking or diffusion period is needed to turn out uniformly clean, carburized parts. When hardened, both the carburized and through hardening steel machine parts must be within ± 1 Rockwell C.

An interesting job performed in this furnace is the carburizing of parts made of modified Krupp (3312) steel. Because of its composition, this steel requires a somewhat different heat treatment than the other alloy steels; it will not harden properly after direct quenching from the carburizing heat. The carburizing and hardening cycle employed by Waterbury for this steel is:

1. Carburize at 1700 F in lithium carburizing atmosphere
2. Oil quench directly from the carburizing heat
3. Reheat to 1200 F and slow cool (the work is usually furnace cooled)
4. Reheat to 1420 F and oil quench (resulting hardness is 64 Rockwell C after tempering at 375 F)

A large number of parts are processed through this treatment, and the hardened parts are given 100% inspection for hardness before they are permitted to leave the heat treating department.

During the daytime, when this furnace is used for hardening, work-pieces of varying sizes, shapes and steels are heat treated. Uniformly clean and hard work has been obtained with oil-hardening steels. In the case of water-hardening tool steels, a thin (submicroscopic) soft skin has been found on the hardened work-pieces. This phenomenon is, as yet, unexplained, but being such a thin skin, it is readily removed by grinding. That this skin is due to faulty quenching practice has been considered, and to date no real explanation has been proposed.

The Waterbury furnace has a pressed steel muffle approximately 24 by 18 in. and 6-ft. long (about 4 ft. is considered to be the actual useful working length of the muffle). Manufactured gas from the city mains is used for heating and for the protective gas curtain at the door of the furnace. Circulating city water is used to cool the condenser.

The daily maintenance for this furnace includes cleaning the atmosphere distribution tube (to remove soot) and the replacing of the two spent lithium cartridges. The present muffle has been used for 18 months and shows no signs of failure.

Treating Propeller Blades

Because of the extremely vital part that a propeller plays in the safe operation of an airplane, no scale or decarburization can be tolerated on a steel blade. The Hamilton-Standard Propeller Div., United Aircraft Corp., East Hartford, Conn., manufactures hollow steel blades for large aircraft propellers. It is felt that the present sequence of operations (making for high production of these propellers) would be impossible, if it were not for the use of lithium atmospheres. But to make the story complete, the early operations on these blades at the Wallington, N. J., plant of the Tube Reducing Co. should be discussed first.

A rough chromium-molybdenum steel slug, 43-in. long with an OD of 6 in. and a wall thickness of ⅞ in., is the raw material used by Tube Reducing Co. The first operation is a spheroidizing heat treatment in lithium pit type furnaces with neutral atmospheres. By cold reduction, in three passes, this slug is then formed into a tube that finishes to 127 to 129 in. long and having a wall thickness varying from ½-in. at the base to 0.046-in. at the tip end after machining. Between each pass, the tube is stress relieved in a neutral lithium atmosphere in a pit type furnace at 1250 F. Several of these stress relieving furnaces are shown in Fig. 4; the fixtures for holding the tubes in a vertical position can be seen along the right. Some slugs from which small hollow steel propeller blades are made can be seen standing in the upper left part of the picture.

The atmosphere in these furnaces is such a lean mixture as to be non-explosive, an important consideration when loading and unloading 5 ft. dia. x 10 ft. deep furnaces under a high production schedule that allows no time for purging furnaces of any explosive gases.

The carrier gas (the cracked propane) has the following composition prior to passing through the lithium generators at Tube Reducing Co.:

Carbon dioxide	6.5%
Carbon monoxide	10.2
Hydrogen	11.5
Methane	0.4
Nitrogen	Bal.

After this gas passes through the lithium generator, (where it picks up the powerful lithium vapors) it has a most important effect on the steel work-pieces. Hot stress-relieved tubes can be removed from these furnaces and allowed to cool in the air without either decarburization or scaling. Besides furnishing scale-free and decarb-free work, it means that no cooling chambers are needed, nor must the tubes be cooled in the protective atmosphere of the furnace. Thus, the equipment is only used for the most essential purposes, conserving both equipment and processing time.

The machining sequence on the formed tubes is as follows:

Bore the ID
Center and turn the OD concentric within ± 0.0005 in.
Finish all other surfaces
Hone the ID
Magnaflux inspection
Thread mill the ID at base end.

The formed tubes are shipped from Tube Reducing Co. to the Hamilton Standard Propeller Div. of United Aircraft at East Hartford, Conn. Here the tubes are heat treated in a series of lithium furnaces.

This lithium furnace installation is unique for two reasons. One is that Hamilton Standard is probably the largest producer of hollow steel propeller blades in the world and, therefore, the manufacturing processes used in the making of these blades is one of the most efficient and carefully controlled processes in operation in the aviation industry. The second reason is that the furnace equipment was especially designed to utilize a new principle (the lithium atmosphere) in a wholly novel type of furnace.

A general overall view of these furnaces is given in Fig. 6. The cores of the propellers in various stages of completion can be seen standing on the floor on both sides of the control board in front of the first furnace. Some envelopes can be seen on the dolly in the center. The location of the lithium cartridges is shown in Fig. 8. This is a view along the side of the furnace; in each of the oval depressions the tops of two lithium cartridges are visible.

It was mentioned previously that a change in the air-gas ratio was the only control needed over a lithium atmosphere. The efficiency of this control is concretely illustrated by the results of a 30 day decarburization test run in a horizontal muffle, neutral lithium atmosphere furnace.

Fig. 4—View of the side of a carbon restoration furnace at Hamilton Standard. The lithium cartridges, in sets of two, are placed in recesses. Cartridges are changed every 24 hr.

Economics of Lithium Furnaces

As the furnaces used with lithium atmospheres are substantially similar in construction to those built by other manufacturers, their purchase price is about the same. This means that the cost of the lithium atmosphere will be the governing factor when comparing lithium furnaces with those of competitors on a cost basis. A typical analysis of the operation costs of carburizing in a pit type lithium furnace is summarized below:

Furnace load: 1000 lb. of 0.020 to 0.25% carbon steel
Carburizing temperature: 1650 F
Carburizing time: 4 hr. to bring furnace load up to heat plus 2 hr. at heat

Cost of city gas per hr.:	
Furnace consumption, 150 ft.^{3}/hr. @ 0.50/1000 ft.^{3}	= $0.075
Cracker consumption, 60 ft.^{3}/hr. @ 0.40/1000 ft.^{3}	= 0.024
Lithium generator consumption, 25 ft.^{3}/hr. @ 0.40/1000 ft.^{3}	= 0.010
Cost of city gas per hr.	$0.094
Cost of propane:	
Propane consumption 3 ft.^{3}/hr. @ $0.30/1000 ft.^{3}	= $0.0009
Cost of electricity:	
Electricity used, 2 kw. @ $0.02/kw.	= 0.04
Cost of water:	
Cooling water used, 30 gal./hr. @ $0.12/1000 gal.	= 0.0036
Cost of "Lithium cartridge":	
Two cartridges consumed in 24 hr. @ $1.85, therefore cost/hr. = $\frac{2 \times 1.85}{24}$	= 0.154
Total (of above items) cost, per hr.	$0.308

Depreciation, rent, overhead, etc. is not included as these figures would be the same as with most other comparable furnaces.

The rate of carburization is also of considerable economic importance when discussing the cost of carburizing. It is given as:

0.020 in. for the first hr.
0.014 in. for the second hr.
0.010 in. per hr. thereafter

The lithium furnace installations that have been described above are typical of many others in service, and they indicate the range of usefulness to industry of lithium atmospheres. The present lithium heat treating atmosphere, composed of cracked propane (as a carrier gas) and lithium vapors, has a definitely wider range of uses than that of any other single furnace atmosphere. This particular type of atmosphere likewise has its limitations; it has not proved suitable for heat treating stainless steel nor for the hardening of high speed steels. Investigations are being undertaken, however, by the Lithium Co. to find suitable carrier gases so that the advantages of the lithium atmosphere may be extended to the heat treating of these and other metals and alloys.

The use of magnesium for principal castings in a portable chest X-ray unit reduced its weight by 300 lb. over previous sheet metal model.

View of complete group-survey X-ray unit developed North American Philips Company, Inc.

Portable X-Ray Unit Utilizes Magnesium

by **WILLIAM KES**, *Senior Mechanical Engineer, Engineering Laboratories, North American Philips Company, Inc.*

THAT MAGNESIUM WILL PLAY an important role in the development of new postwar products is an admitted certainty. The new Philips medical X-ray unit, designed to handle large groups of people for TB chest examinations, is an outstanding example of the trend towards magnesium.

This chest survey apparatus consists chiefly of the X-ray tube with its power supply, the fluoroscopic screen, the automatic 70-mm. camera, and the control stand. In operation, the image on the fluoroscopic screen is photographed in miniature size on a roll of film which accommodates 350 exposures. On many assignments 200 to 300 individuals per hr. have been X-rayed accurately and efficiently. Where the 70-mm. picture indicates the need for re-examination on conventional 14 x 17-in. X-ray plates, the work can be done on this same unit.

Portability was of utmost importance in designing the group survey X-ray apparatus. Weight had to be held to a minimum value. In addition, assembly and disassembly operations could not exceed 15 to 20 min., including time for packing and unpacking.

After a thorough study of all suitable materials, magnesium was selected as the basic metal from which to fabricate the main assembly castings. This selection resulted from the following considerations:

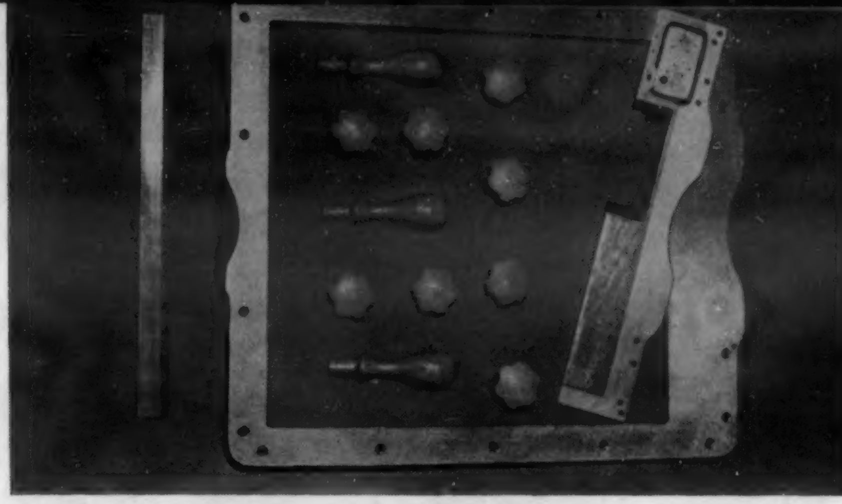
1. *Light Weight:—*

Where light weight is of importance, magnesium castings frequently will be found to be the answer. Magnesium weighs approximately 1/4 that of iron and 3/5 that of aluminum. This light weight of the basic material permits, in castings, the application of thicker sections, larger fillets, added stiffening ribs, and yet is appreciably lighter than if made of any other metal. A magnesium casting with a wall thickness 50% more than an aluminum casting would weigh no more than the aluminum castings. One of the outstanding characteristics of magnesium is its low elastic modulus, 6,500,000 psi. This, combined with an exceptionally high tensile strength, creates unusual design problems.

2. *Design Problems:—*

Magnesium parts must be designed with far more attention to strains and deflections than parts made of other materials. Parts not properly designed for stiffness may deflect excessively, possibly transferring loads to associated members and causing a failure. In addition to the low elastic modulus, special consideration must be given to the low shock resistance of magnesium as compared with aluminum. These two factors require that castings be designed with large fillet radii, about twice those that would be used for iron castings, and with generous tapers from heavier to lighter sections. Fortunately, the necessary provisions to compensate for low elastic modulus and low shock resistance are similar. The above should not present a problem to any designer who attempts to use magnesium since its high resiliency

View of magnesium castings used in Philips X-ray unit assembly.



View of silicon-aluminum parts used in Philips X-ray apparatus which handles TB chest examinations for large groups.

makes it suitable in light weight members requiring good capacity for energy absorption. This obviously, in portable equipment, is of utmost importance.

3. *Machining:—*
Magnesium alloys, in general, have excellent machining characteristics but with some essential machining practice differences, as compared with other metals. These are due chiefly to lower cutting resistance, lower specific heat, lower modulus of elasticity, and the chemical properties of magnesium. Speed of machining, depth of cut, type of cutter, rough cut, finishing cut, ease of clamping part rigidly in place, use of cutting fluids, methods of grinding, hazards of fire, etc., all these items are of no unknown mystery and an answer to proper machining can be found in any shop handbook or data book furnished by the manufacturers of magnesium. We have found it more economical to machine magnesium than any metal we have worked with to date.

4. *Availability:—*
Today, there is an ample supply of material for all users of magnesium. Many foundries with "know-how" gained during World War II in manufacturing aircraft parts are available for peacetime production.

5. *Cost:—*
Although higher in price per pound, magnesium holds its own when compared with other metals on a volume basis, plus the savings in simplified patterns and more economical machining.

It was our intention, in listing the above five important considerations, that we show the ease with which magnesium can be adapted to your designs and equipment. We have, since the design of the above referred X-ray apparatus, adapted many more new designs to the use of this light weight metal.

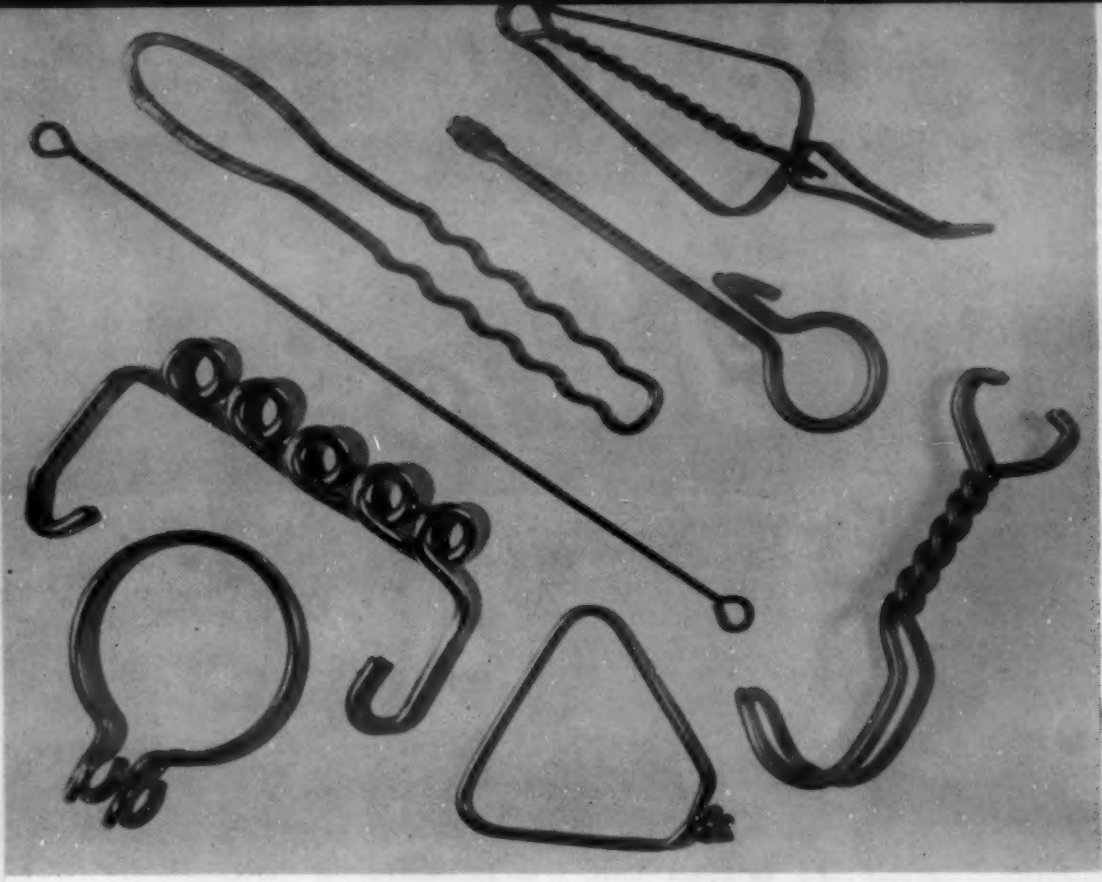
In developing the original design for the medical X-ray unit, a complete working model was constructed. Exact in every detail, this experimental apparatus was turned over to the U. S. Public Health Service and utilized for chest examinations among thousands of people in the New York metropolitan area. The original unit was fabricated by hand almost entirely of sheet metal. Where wall thicknesses on the sheet metal model were (in many instances) only 1/16 in., the ultimate design specifies magnesium castings with 3/16 in. as a minimum measurement. In spite of this increase in volume, the magnesium unit weighs 300 lb. less than its sheet metal predecessor. Consider the gratitude of X-ray technicians whose packing and handling task was lightened appreciably.

Because the chest-survey unit must be set up and disassembled quickly under the most adverse conditions, the number of parts has been held to a minimum. No tools are required and no group assembly in the mechanical section weighs more than 80 lb. Obviously, this discussion does not concern the transformer, rectifier, control stand or the protective screen.

Certain special parts on the X-ray apparatus are made of silicon aluminum S.A.E. 35. These include knobs, handles and the frame on the fluoroscopic hood. Silicon aluminum lends itself well to buffing and polishing, and retains a high lustre without plating or lacquering. Magnesium which has been polished and lacquered will tarnish and assume a dull gray color if the protective coating wears or chips off. Silicon aluminum dresses up a unit and retains its high lustre under all normal conditions. Physical characteristics are about the same as for other aluminum alloys.

The Philips chest-survey X-ray unit may well point the way for other manufacturers who are hesitant about using the new wonder metal—magnesium. It has taken the strenuous beating accorded to any portable apparatus. It has withstood one-a-day, day-after-day setting up and dismantling routines; it has been in and out of schools, factories and every other type of location. In most cases, it has been handled by female technicians who have labeled it an outstanding contribution to the medical profession.

Grateful acknowledgement is made here for valuable assistance extended by Eclipse-Pioneer Division of Bendix Aviation Corporation. Their war experience with magnesium castings has helped greatly in the design of the Philips group-survey X-ray unit.



A group of Eastern Tool staple products, including a double-eyed stem, twisted hook, special tweezers, and a special ring hook.

Wire and Ribbon Forms

by HERBERT CHASE

WHAT THE WIRE FABRICATING TRADE calls "wire forms" constitutes an immensely important type of metal product. Total production runs into many billions of pieces annually and involves so many commonplace items that even those generally well informed about metalworking rarely stop to inquire how these items are manufactured, much less to find out why they are made as they are or what factors enter into their design and manufacture. Even the designers of complex products that may include scores of wire forms rarely know how the forms are made or what should be done to insure designs that will yield most per dollar expended.

Inquiries along these lines quickly reveal that there are uncounted types of wire forms and that there are numerous types of machines for manufacturing products of this character. Some machines make only highly specialized wire forms, such as particular shapes of chain links or staples of standard pattern. Cold headers produce another class of wire product. Many wire forming machines run continuously for months at a time almost unattended, making thousands of pieces an hour. It is small wonder that such products, although they affect almost everybody's life in uncounted ways, are so commonplace as to be taken for granted.

Wire forms (considering the product rather than the form around which they are shaped) are made most often from wire of circular section, but there is a large output also from non-circular wire and of narrow strip or flat stock classed as "ribbon." The same machines are often used for several types. Although, broadly speaking, wire forms may include helical and other coiled springs, these are excluded from this discussion, as are also products that are primarily headed without being formed.

Dealt with here are such items as clips of many types, chain links, staples, pins having bent forms, hooks of many types; garter, suspender, belt and similar slides, buckles and fasteners; rings and loops; button shanks, cotter pins, bails, screw eyes and other parts with eyes; hose and other clamps, holders for candles and other products and thousands of springs (other than coil springs) and special elements for metal products as well as for those made primarily for use with fabric, wood, leather, paper, glass, plastics and other materials.

One large maker of wire forms produces them from round wire ranging from 0.005- to ⅜-in. dia. and from a fraction of an inch to 36-in. long. Ribbon stock up to 2½-in. wide and ⅛-in. thick is also handled through wire forming machines by this company. Both wire and ribbon are formed from steel as well as from numerous types of nonferrous metals.

Conventional wire forming machines have four

slides, in an average case. Each slide carries one or more sections of a die. As these sections advance, they close around a central form which commonly has about the size and sectional shape of the space that the formed wire encloses. This central form is, in effect, the male element of the die, being somewhat analogous to the punch of a stamping die, but is commonly fixed rather than movable. Each slide is reciprocated by a cam which controls its motion in correct sequence and synchronization with other die and machine elements.

An average machine operates as follows: The wire is drawn from a reel through straightening rolls by a feeding device that advances the wire against a stop. At the end of the feed, the wire is sheared off by a cut-off knife and the length of wire is held momentarily against the form. As the front slide advances its die section bends the two ends around the front face toward the right and left sides of the form. Immediately thereafter the right and left slides are advanced and their die sections press the two end portions of the wire against the two sides of the form and often part way around the back of the form. Next, the rear slide is advanced and its die section commonly completes the forming by forcing the reamining short end sections against the back of the form.

All four slides are then withdrawn and a stripper around the form is lowered to push the formed wire down the form and, in most cases, off the form. If the forming is not completed, however, the partly formed part may be arrested at a lower level (or even, in succession, at each of two lower levels) where one or more other portions of the die perform other forming. The partly formed piece at the second and third levels, when they are needed, is commonly formed at the same time that a new length of wire is formed. Thus, in general, a completely formed part drops from the machine at the end of each complete cycle.

Most frequently, the forming is in one horizontal plane but, by properly shaping the die sections or by using a tool on the stripper to do some forming, bends in any plane can be made. It is also possible to add attachments to perform other operations, such as curling the ends of the wire one or more times around pins to form loops or coils and then withdrawing the pins; twisting the wire in various ways or interlocking one formed wire part with another or with a stamped and formed element.

Wire forms are so commonplace that one seldom questions how they are made or considers what should be done to insure economical production.

Many wire forming machines include small presses that perform one or more operations either on the wire or ribbon before it is formed or on the formed part. These include the formation of flats, the piercing of holes, the upsetting of some portion, the formation of notches or recesses, or even the assembly of some second part to the wire form. Quite often, the formed part is shifted automatically into dies in the press to perform an operation that cannot be done in the forming position.

Besides the attachments mentioned, there are various cut-off attachments for making cuts at an angle, nail point cuts and secondary cuts and other attachments for winding, milling, welding and doing other operations in cooperation with or independent of other elements of the machines. It is not unusual for a machine to be rigged to form a wire part, such as a square ring, and also a part cut from ribbon metal, such as a short tube, and assemble the tube around one side of the ring.

Literally hundreds of special attachments are made by individual users of wire forming machines and, as some of the large users have thousands of different dies, it is not surprising that the variety of products turned out is almost infinite. One maker of wire forms catalogs some 3,000 "staple" items that are available from more or less "stock" dies and produces a still larger assortment of "special" wire forms in special dies made for individual customers.

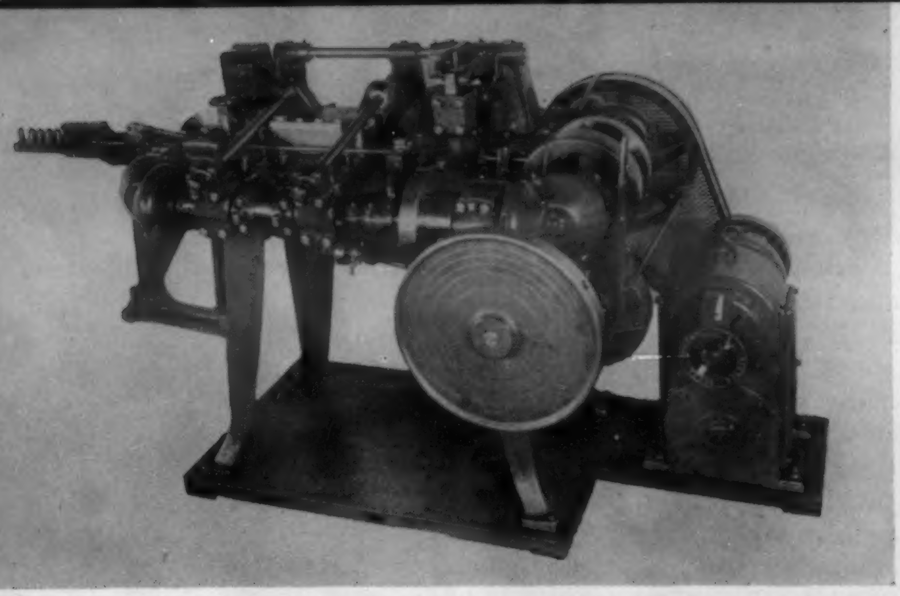
Materials Used

By far the largest production of wire forms is in low-carbon steel, but there is extensive use of piano wire and other high carbon steel and of alloy steel of many types and grades, including stainless steel. Some is formed soft and hardened later but a great deal is formed from wire that is already hard.

As hardness is rarely uniform, even throughout the length of individual coils, spring-back varies and is difficult to predict. In consequence, tools commonly require repeated trials before desired results are secured and may need frequent readjustment during the course of a run, especially when close dimensional limits are set.

Although steel wire is easiest to work when in an annealed conditions—there are cases in which it can be worked satisfactorily only in this form—subsequent heat treatment, if needed, can result in warpage or in unfavorable effects upon finish. These considerations frequently make it better, when possible, to work with wire already hardened and having the desired surface finish than to start with an annealed product and harden it by later heat treatment. Naturally, the particular specifications to be met often influence the choice not only of the material but of the processing to be followed.

Steel wire is available, of course, with or without bright finish and with acid copper, galvanized or tin coatings among others. As the specifications often call for plating or other finishing after forming, it is desirable to start with wire such as will yield the required final finish at minimum over-all cost and still fulfill other requirements.



Typical Nilson four-slide wire forming machine with a press designed to produce flats, pierce, form notches before or after the wire has been formed.

The types of wire and ribbon used in wire forms depends upon whether or not these forms have spring applications. A large proportion of wire forms are classed as springs and require the use of high carbon steel wire, stainless steel and nonferrous wires and ribbons with spring temper in about this order of importance. If the forming is severe, wires are used in the soft state and the forms are hardened subsequently, if it is required that the forms be in hardened condition. When the wire form is not required to act as a spring, it is commonly made from low carbon steel wire, soft ferrous or soft nonferrous alloys.

For wire forms having spring action, the grades used, in order of importance are:

High carbon tempered (0.41 to 0.85% carbon) steel
Untempered high carbon (0.41 to 0.70% carbon) steel
Annealed high carbon (for subsequent tempering) steel
Stainless 18:8 steel
Other alloy steels
Nonferrous materials

For wire forms not having spring action, the grades used, in order of importance, are:

Hard drawn basic or Bessemer (low carbon) steel
Annealed low carbon steel
Stainless steel
Annealed nonferrous metals

When forms are to be made from precoated wire or ribbon, zinc, copper or tin are the more common coatings, although painted strip is becoming increasingly popular. Where coating is done subsequent to forming, the most common electrolytic finishes are cadmium, zinc or tin but baked japans, enamels, paints and oiled oxide or phosphate coating are often supplied. Many forms are supplied without coatings and the purchaser can apply one separately or after assembly, say when the unit containing the form is finished. The choice of finish is usually dictated by the appearance required or by the degree of corrosion resistance afforded, or both.

Electro-deposited coating are commonly furnished in thickness ranging from 0.0003 to 0.0005 in., which is considered commercial. Thicker coatings are available at increased prices. For other types of coatings, no thickness limits are specified, as a rule, although the minimum resistance to corrosion, as indicated by hours of resistance to salt spray under specified conditions is sometimes used as a yardstick. Oil commonly used over oxide and phosphate coats presumably increases their corrosion resistance.

Besides data on the shape, general dimensions and size of wire required, the purchaser of wire forms should indicate what load the form must support or is likely to be subjected to in service, the essential dimensions and tolerances, the character of service, including allowable deflection under load, the pressure that the form must exert, if it is a spring, and the conditions of exposure. Samples of the form and of the parts with which it is used are helpful, as are also data on the motion required in application and in service and on the fatigue properties or life expectancy anticipated.

Wire sizes should be indicated by gage number (American Steel & Wire, originally known as Washburn & Moen). The physical properties and compositions of steel wires commonly furnished are as given in accompanying tables.

On cold rolled strip, commercial thickness tolerances run from ±0.005 in. on stock as thick as 0.249 in. and as wide as 24 in. to ±0.001 in. on stock as thin as 0.010 in. and 3/16-in. width. Width tolerances depend upon the edge that is specified.

Wires of circular section are commonly ordered according to the range of tensile strength rather than according to hardness. On the commercial product, a speed of 20,000 to 30,000 psi. tensile strength is ordinarily permitted.

Strip (ribbon) is commonly ordered by "temper" number, as follows:

No. 1, Hard, for flat work only
No. 2, Half-hard, will take right angle bend across grain
No. 3, Quarter-hard, will bend upon itself across grain and fairly well with grain

Commercial Tolerances on Circular Steel Wire

Size Wire	Drawing			
	Regular	Semi-Special	Special	Extra Special
½ in. and Coarser	±0.003 in.	±0.002 in.	±0.0015 in.	±0.001 in.
½ in. to No. 14 (0.076 in.)	±0.002 in.	±0.0015 in.	±0.001 in.	±0.0005 in.
No. 14½ to No. 20 (0.034 in.)	±0.001 in.	——	±0.0005 in.	——

No. 4, Pinch pass or skin roll

No. 5, Dead soft, will bend upon itself either across or with grain.

Tempered strip is commonly ordered as such, the heat treatment being such that, for a given thickness and carbon content, a given hardness prevails. Special tempering cycles are sometimes requested but are not conducive to quick delivery or to low cost.

Close cooperation with makers of wire forms often results in substantial cost reductions without sacrifice in quality or performance. Naturally, if the form is one that can be produced on a completely automatic machine, the cost is correspondingly reduced unless tooling costs become excessive for the quantity required. Except where quantities are so small that tooling costs become excessive, costs are lowered by avoiding shapes that require hand operations. There are cases, however, in which a combination of machine and hand operations result in minimum over-all cost.

There is, of course, a great variety of nonferrous wire that is well suited to forming but, unless the desired final properties can be developed by heat treatment or by working incident to forming, the wire must be given these properties before forming is done. Nonferrous wire suitable for springs include spring brass, nickel silver, phosphor bronze, silicon bronze, Monel, Inconel, K-Monel, Z-nickel and beryllium copper.

Where strength and stiffness are of little or no importance, an almost unlimited variety of nonferrous alloys and numerous pure metals can be made into formed wire parts. Many of these metals and alloys are high in corrosion resistance and others do not require plating to meet appearance requirements.

Production Rates

Wire forms are commonly produced at rates ranging from 15 to 500 a min. The speed of production generally decreases as the diameter of the wire and the length of wire per piece increase. Exceptional complexity in the piece or the addition of any process that is slow in itself tends to lengthen the normal cycle of the machine and to reduce output per hour.

Although many wire forms do require secondary operations, which are independent of the primary forming machine and so do not affect its speed, it is a common objective in wire forming to complete the product in the forming machine if this can be done. Naturally, if the addition of a slow operation requires that the machine run slower, so that other operations are also lengthened, output is lowered accordingly.

Some secondary operations can be done on fast automatic or semi-automatic machines but they are likely either to increase handling charges or to require some special tooling (such as the provision of a special hopper or transfer device) that increases over-all costs.

Wire forming machines are properly classed as fast producers and their hourly output rivals that of light fast stamping presses. In fact, products made from ribbon stock on wire forms are sometimes duplicated on stamping presses alone and, since many wire forming machines include small stamping presses, the two are in much the same category.

In wire forming, scrap losses range, as a rule, between 2 and 10%, the percentage increasing, in general, as harder wire is used. Most of the scrap produced is not in ends or in material cut into chips, as these losses are slight, but in parts that do not come within dimensional limits, perhaps because hardness and spring-back vary or because distortion takes place in heat treatment. Naturally, where wide dimensional tolerances are allowed, scrap is likely to be less than when limits are narrow.

There is, of course, no fixed cost for tooling. Charges on this score range from a few dollars up to $2,000 or more for complex parts for which unusually close dimensions are specified. In general, the purchaser pays the first cost of tools after which they are maintained without extra charge by the company making the wire forms. Setup charges are commonly added whenever tools are put into use for a new run.

Tools are made ordinarily from high carbon steel that is hardened and ground, but alloy steel is also used. Wear is usually not rapid unless the tools have to make sharp bends or to perform a forging operation in which considerable flow of metal is involved.

Design Considerations

No unvarying rules for the design of wire forms can be prepared any more than they can be for the design of other products intended for quantity production. It is possible, however, to list several things that it is desirable to do and to avoid doing with the objective of minimizing cost. But, in so doing, it should be understood that such "rules," if so called, have many exceptions and should be followed only when the advantage gained by so doing outweighs whatever advantage may be realized by a feasible alternative. The following rules are subject to these limitations but might serve as a list against which designs can be checked to see that no possible advantages are overlooked.

1—The design should not call for a greater length or a larger size of wire than is necessary to meet performance requirements.

This tends to minimize the total length and weight of wire needed.

2—Dimensional limits should be no closer than necessary.

This is of special importance with spring or other hard wire in which the dimensions can not be easily controlled because of variable spring-back. If wire is annealed when formed and requires subsequent heat treatment, there may be some resulting distortion such as will require extra operations or result in excessive scrap if dimensions have to be held within close limits.

3—Allow an inside radius at least equal to wire diameter (or thickness) unless assured that a sharp bend is feasible without undue extra cost.

Short bends may result in fracturing or weakening the wire or result in a notch effect such as will result in subsequent failure. Wire that is soft and ductile sometimes can be bent at a sharp right angle but then thins out at the bend. An outside radius must be

at least equal to wire diameter or thickness unless a special coining or other expensive forging operation is performed.

4—Avoid bends closer than 1½ to 2 diameters from the ends of the wire form unless extra costs for trimming after forming are fully justified.

Bends unduly close to the end of a wire are difficult if not impossible to make but, if extra costs for secondary trimming operations are warranted, the wire form can be made with longer ends that are trimmed off after bending. This, however, results in waste and an extra operation.

5—Bend should be in one plane, or substantially so, unless other considerations warrant whatever extra costs may be involved in making bends in more than one plane.

There are, of course, many cases in which bends in two or more planes are fully justified but they are likely to increase tooling and setup costs or involve higher costs on other scores.

6—Stick to the simpler designs that tend to lower cost and can be made to meet essential requirements.

Complex shapes usually add operations and make tooling and setup costs higher, often necessitating special attachments. There are many cases where the benefits gained warrant this extra cost, but if a simpler solution of the problem that yields a lower cost without undue sacrifice on other scores can be found, both tooling costs and piece costs may be lowered.

7—The design should be such that the product can be completed in one machine, preferably one of the simplest and fastest type.

Designs that are completed in one machine, preferably without extra attachments, usually involve minimum handling and lowest cost. Simple machines usually involve less tooling and lower tooling cost. If the machine requires, say, a press to do some flattening, upsetting or other work that could be avoided, extra dies, a transfer attachment and extra setup and maintenance charges are incurred. Often, these yield advantages that fully justify the extra cost, but, unless they do so, the added cost is not warranted.

8—Avoid designs that require two or more deep U-bends side by side to be formed by one stroke of a single slide.

Such multiple bends can be formed, in general, only in sucessive strokes of one slide with a feed between, as the wire will break or be very much stretched otherwise. A succession of shallow bends permits the wire to slide or be stretched much less and is entirely feasible. Although a setup for successive deep U-bends made one at a time is feasible, it requires a very special setup that is not adaptable to rapid production on ordinary machines.

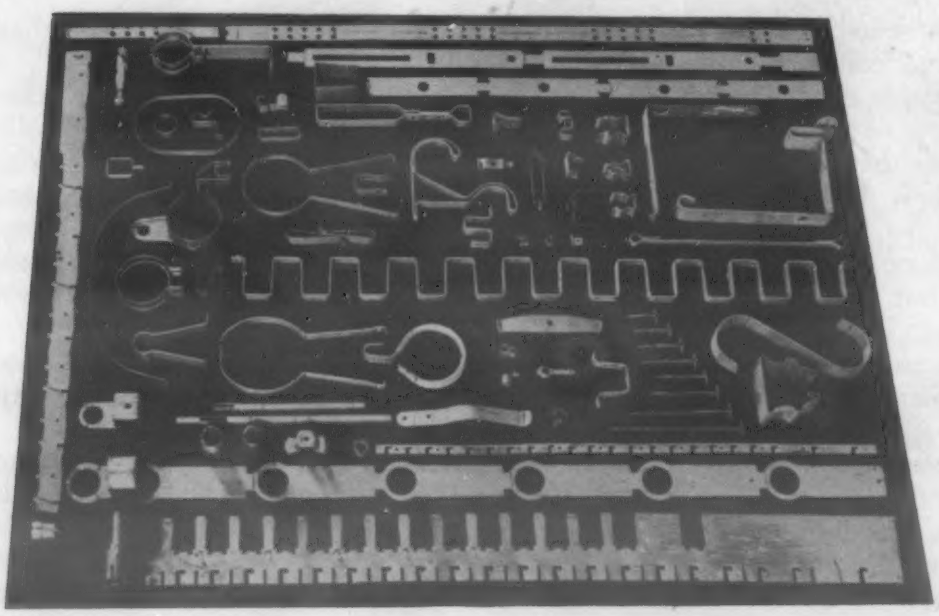
9—Do not specify such operations as necessitate cold forging (such as flattening or upsetting) or notching or piercing unless whatever advantages might be gained fully justify such extra cost as is involved.

Although such operations frequently result in net advantages, they are likely to increase tooling and setup charges and to involve the use of a more complex machine or of extra attachments. These, in general, increase over-all costs but these costs often are fully warranted by providing a product better adapted to specific uses.

10—Submit design and specifications to a maker of such forms or to someone familiar with forming practice for constructive suggestions that may lower costs or improve functioning of the product.

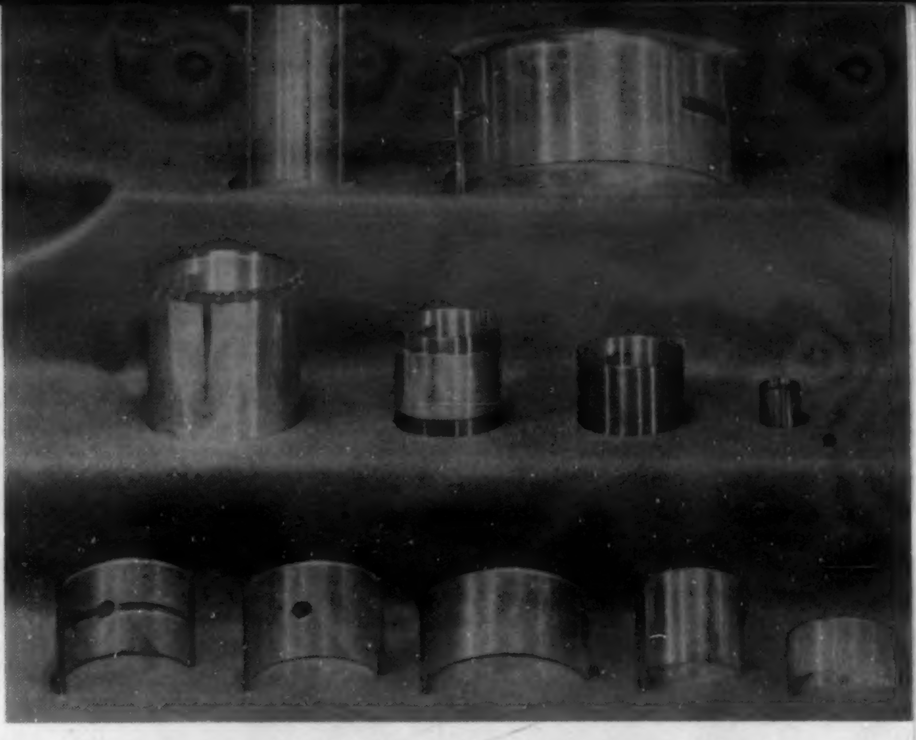
Advantage should be taken of the experience of specialists who know what troubles can be encountered in production or subsequent application. Since most designers of wire forms are not familiar with details of production, many of which have important effects upon costs, and may not know of alternatives that will lower costs or avoid subsequent trouble, the chance of profiting by following this rule is considerable.

Even if the recommendations made are not followed, they may suggest feasible changes that will improve the product or lower its cost or both. The earlier in the design that such recommendations are sought, the less they may affect mating parts and the more may be gained by following the practice.



Wire forms made from ribbon on a Nilson machine. Besides being formed, the parts have pierced holes or notches produced in the press unit of the machine. Strip at bottom is in a partly completed stage.

Because of many favorable characteristics, recently developed aluminum alloy bearings are receiving marked attention for heavy-duty application.



These represent some of the steel-backed aluminum alloy bearing forms produced by the Al-Fin process.

Aluminum Alloy Bearings for Heavy-Duty Applications

by H. R. CLAUSER, *Associate Editor,* MATERIALS & METHODS

IN RECENT YEARS there has been a concentrated search for better bearing materials for heavy-duty service. Particularly in the automotive and aviation field, materials for bearings which will give better performance and longer service life are constantly sought. The most recent result of this search has been the application of aluminum alloys to bearings.

Development work and experiments with aluminum alloy bearings are being conducted by many companies—both metal and bearing manufacturers—all over the country. There are very few specific performance data available as yet, since many companies working on the aluminum bearing projects have not completed their investigations and so are not prepared to publish their results. However, it is possible now to discern the significant features and broad aspects of the aluminum bearing picture.

This article is intended to serve as a progress or status report on the subject, and will review the development work thus far accomplished. Many test and performance data are still forthcoming. As soon as this information becomes available a more complete and final appraisal will be made.

History of Development

In the development of materials suitable for use as bearings many bearing requirements or characteristics must be considered. These, briefly, are:

Anti-friction characteristics. These include the ability of the bearing to resist scoring, galling and seizure when, in the momentary absence of the oil film, the clean metal surfaces of the journal and bearing come in contact with each other.

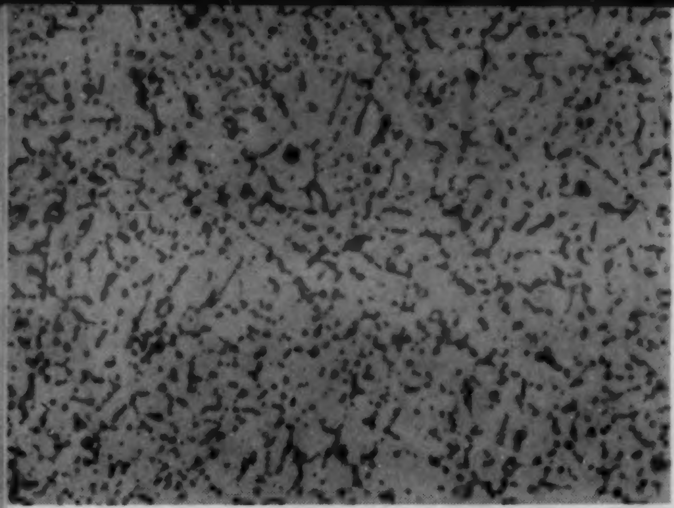
Load carrying characteristics. The bearing must carry imposed bearing load without permanent deformation. At the same time the bearing must have *conformability,* being plastic enough to yield and conform to high local pressures caused by local imperfections and slight misalignments. The bearing must also possess the characteristic called *embeddability*—the ability to embed a grit particle and keep it from scoring the journal.

Fatigue characteristics. Since bearings operate under dynamic stresses, bearing life is largely determined by its fatigue resistance.

Corrosion characteristics. It is necessary that the bearing material resist corrosion from bearing lubricants at the operating temperatures.

Wear characteristics. The wear resistance of a bearing, although important, is largely dependent on the other characteristics, such as corrosion resistance, strength and hardness, and anti-friction characteristics. It is also affected by operating conditions.

Until about 1937, the use of aluminum-base alloys for bearings was generally restricted to those applications involving service under light loads against hardened shafts with good lubrication. Early developments in Germany and England followed the classical bearing metal theory of a heterogeneous



Typical structure of chill cast aluminum-tin-silicon-copper alloy after heat treatment (100X).

The bearing surface of a similar alloy after operation. Bronze (broken lines) and steel (solid lines) have embedded successfully (10X).

structure consisting of hard crystals embedded in a soft matrix.

Early aluminum bearing alloys contained combinations of copper, iron, silicon, nickel, manganese, antimony and cobalt to provide the hard load-supporting crystals. More recent German aluminum bearing alloys not only had hard particles but also a hard aluminum matrix. Such hard aluminum alloys were inferior in their resistance to scoring and galling and were not satisfactory for heavy-duty service. Later German developments attempted to improve score-resisting qualities by adding low melting metals, such as lead, or by graphite impregnation.

From time to time during the past ten years or so, aluminum alloys containing concentrations of tin up to 26% with smaller amounts of copper, nickel, manganese, antimony and magnesium have been experimented with, particularly in England. By 1939 some of these alloys were used with reasonable success for connecting rod and main bearings in Rolls-Royce products.

Early tests in this country generally verified European conclusions that the "hard" type aluminum base alloys could be used as connecting rod or crankshaft bearings only under moderate bearing pressures and temperatures, on hardened journals with a minimum of deflection, and with very efficient lubrication.

In this country experimental work has sought to develop aluminum alloy bearing materials for use as solid bearings, steel-backed aluminum bearings, and powdered aluminum alloy bearings. The first two have advanced to the point where bearings are now being commercially produced and are in service. Powdered aluminum bearings are still in the early experimental stages and are not as yet under production. Little can be said about them except that during the war Amplex Div., Chrysler Corp., developed a self-lubricating powdered aluminum bearing equal in performance to self-lubricating bronze bearings. However, at present they are not applicable to heavy-duty service because of their high cost and difficulties entailed in their production.

Solid Aluminum Alloy Bearings

An excellent paper, giving results to date on the extensive development work done by the Aluminum Co. of America was recently presented before the SAE Summer Session at French Lick, Ind., by H. Y. Hunsicker and L. W. Kempf. This paper reports that during the first stages of the development work conducted by Alcoa, the alloying of tin with aluminum was found to improve the anti-friction and corrosion resistance satisfactorily. However, the superior anti-friction and corrosion resistance properties were obtainable only at the expense of the fatigue resistance and load carrying characteristics. Therefore, in order to develop aluminum alloys which might be used as solid bearings, the latter portion of their work was devoted to finding means of improving these other bearing properties.

By additions of small amounts of other alloying agents it was found that under certain conditions sufficient mechanical strength for internal combustion engine applications could be obtained; at the same time, satisfactory conformability and embeddability characteristics could be retained. Thus, two promising aluminum alloys were developed.

The nominal composition of the one alloy is: 6.5% tin, 1% nickel, 1% copper, and the balance aluminum of commercial purity. The nominal composition of the other is: 6.5% tin, 2.5% silicon, 1% copper, 0.5% nickel, and the balance aluminum of commercial purity. The mechanical properties of the aluminum-tin-silicon-copper bearing alloy as determined by Hunsicker and Kempf are given in the accompanying table and may be considered as typical for the two alloys.

Although they have been tested under both laboratory and actual service conditions, these alloys are still considered to be in the "trial" stage. Numerous laboratory tests have been run by the Aluminum Co. of America as well as other organizations to thoroughly evaluate them. The results are now being checked in service tests. Most of the performance test data is still incomplete, but from the data now available a general evaluation of these aluminum alloys as solid bearing materials for high-duty service can be made.

The ability of the aluminum alloys to resist scoring and seizure under emergency conditions of metal-to-metal contact and thin-film lubrication has been found to be at least as good as any of the other conventional bearing materials. Laboratory tests by the Aluminum Co. using the scuffing test developed by General Motors, showed the aluminum-tin-silicon-copper alloy to be superior to babbit (90 tin, 5 copper, 5 antimony) and copper-lead (55 copper—45 lead) bearing materials.

The aluminum alloys (cast, heat treated) have yield strengths of 8000 to 10,000 psi. (0.2% permanent set) at room temperature. With this strength the bearing material can support the stresses imposed by bearing loads encountered in normal heavy duty

Left to right are cast aluminum-tin alloy, steel-backed copper-lead and steel-backed tin babbitt bearings, which were tested in a bearing fatigue testing machine 200, 35 and 21 hours, respectively.

service. However, another factor—mechanical stability—must be considered in applications where solid aluminum alloy bearings are installed in steel or cast iron housings. Since the thermal coefficient of expansion of aluminum alloys appreciably exceeds that of steel or cast iron housing materials, the resulting thermal compressive strains are added to the strains ordinarily developed by the initial interference of the bearing assembly.

Because of these compressive strains (which are in a tangential direction in the bearing) greater compressive strength is required to resist the deformation induced by the initial interference between the bearing and journal plus the thermal compressive strains. By cold working, such as cold reduction of the bearing material, it has been found possible to increase the compressive strength and maintain an interference fit in bearing assemblies having steel or cast iron components and which do not operate at greater than 250 F for extended periods.

The performance of aluminum alloy bearings in regard to their embeddability and comformability characteristics has not as yet been too clearly defined. In laboratory tests as well as limited engine service tests the alloys have generally exhibited their ability to perform satisfactorily under adverse service conditions where there were substantial shaft-deflections and where grit had entered the clearance between the bearing and the shaft. In one case where an aluminum-tin alloy bearing was operated for 660 hr. in a fatigue testing machine, a number of particles of bronze and steel were found embedded in the bearing surface. The general indication is that aluminum alloy bearing materials will not embed foreign particles as well as the softer bearing materials, such as babbitt. However, with good bearing design it is believed that conformability and embeddability of aluminum alloys is sufficient to meet most service conditions.

The evaluation of the alloys' fatigue characteristics has been largely limited to short-time laboratory fatigue tests. No actual service data could be obtained. The laboratory fatigue tests have indicated that the two aluminum-tin alloys should have good fatigue resistance under both normal and severe bearing pressures. A test to determine the relative endurance of cast aluminum-tin-copper-nickel alloy as compared to steel-backed 65 copper—36 lead, and steel-backed tin-base babbitt showed that the aluminum alloy bearing material was definitely superior.

The aluminum alloy bearing materials have excellent corrosion resistance against the organic acids which are formed from the decomposition of lubricating oils. In comparison tests the aluminum alloys have proved to be equal to silver and definitely superior to tin-babbitt, copper-lead and cadmium-silver, in this respect. This ability to withstand corrosive attack by organic acids may permit the use of compound oils in engines. Compound oils, which corrode the other bearing materials, have superior lubricating properties and prevent accumulation of engine deposits and ring sticking.

In the production of solid bearings with these alloys, the permanent mold casting method is generally used. The minimum section thickness possible is around 0.25 in. Connecting rod and crankshaft bearings for such service as trucks and aircraft, are made with as thick a section as possible for optimum strength and fatigue resistance.

Experimental work in manufacturing aluminum alloy bearings by die casting has shown definite promise. It is probable that die casting will be employed for bearing inserts for small engines; also for bushings with wall thicknesses of 0.068 to 0.100 in.

Some experimental work has been done to find a satisfactory rolling practice for producing aluminum alloy sheet for bearing applications. These bearing alloys, if produced in sheet form, would make possible fabrication of bearings by low-cost metal forming methods such as blanking. In rolling it has been found that the required mechanical properties can be obtained by controlling the final cold reduction. A high limit in yield strength must be observed since the conformability characteristics are dependent upon the yield. Should yield strength be too high the conformability of the bearing will be reduced. Yield strengths in cold rolled sheet of about 15000 psi. appear to be best for most general applications.

Steel-Backed Aluminum Bearings

Early work on aluminum alloys as bearing materials showed that the addition of tin gives excellent galling and seizure resistance characteristics, excellent corrosion resistance, and, unsatisfactory load carrying and fatigue characteristics for heavy duty service. The one approach, already discussed, was to find additional alloying agents to improve the load

carrying and fatigue properties. Another approach, which will be taken up now, has been the bonding of aluminum-tin alloys on to a steel backing. In this bearing design the aluminum-tin alloys are depended upon to provide the bearing with the necessary anti-friction and corrosion resistance characteristics, while the steel backing gives the required load carrying and fatigue resistance properties. Prominent in the development of steel-backed aluminum bearings have been Al-Fin Corp. and P. R. Mallory & Co.

Just as with solid aluminum bearings, manufacturers and users are testing the steel-backed type of aluminum bearings. Most of the laboratory testing is now completed, and results are being checked in actual service tests. A general evaluation can be made on the basis of the limited data available.

The anti-friction characteristics and corrosion resistance of steel-backed aluminum bearings are similar to those of the solid aluminum type, and therefore are at least as good as the other conventional bearings, such as copper-lead, silver, tin and lead base babbit. When the binary aluminum-tin alloys are used, the anti-friction characteristics are superior to the solid aluminum bearing alloys. A desirable physical property of binary aluminum-tin alloys is their comparatively soft matrix; for example, Brinell hardnesses of 30-35 (500 kg. load) can be obtained in bearings manufactured by the Al-Fin process using binary aluminum-tin alloys with 6 to 10% tin.

From the few service reports available, the strength and fatigue resistance of steel-backed aluminum alloy bearings has proved to be amply satisfactory under severe operating conditions. The strength and fatigue resistance are, of course, dependent on the steel-backing as well as on the bond between the aluminum alloy and the backing material. In tests on one type of steel-backed aluminum bearings by the Caterpillar Tractor Co., occasional failure of the bond has been reported. However, the number of bond failures with steel-backed aluminum bearings has been considerably lower and the failures less extensive than in steel- or bronze-backed babbitt bearings. The steel-backed aluminum bearings were repeatedly operated at higher temperatures and at more than twice the load carried by the babbitt type bearings.

Typical Room Temperature Mechanical Properties of Hollow Cylindrical Permanent Mold Castings of Aluminum-Tin-Silicon-Copper Bearing Alloy

	Cast Heat Treated	Cast, Heat Treated and Cold Worked (4—¼% Axial Reduction)
Tensile Strength, psi.	22000	23000
Yield Strength in Tension, psi.*	9000	17500**
Elongation in 2-in. Gage Length, %	10	7
Yield Strength in Compression, psi.*	9000	17000**
Brinell Hardness	45	50
Rockwell "H" Hardness	75	90
Shear Strength, psi.	14500	—
Endurance Limit (500,000,000 cycles), psi.	9500	—

** 0.2% permanent set* *** In the tangential direction*

The problem of mechanical stability of the bearing in the housing over the range of operating temperatures is always of major importance. In solid aluminum bearing applications where the housing material is steel or cast iron it has already been noted that this is a critical problem because of differences in expansion of the bearing assembly parts. This problem is reduced considerably with the steel-backed type of aluminum bearing. The difference in expansion between the housing and bearing is less, because it is controlled by the steel backing. In addition, the elastic limit of the bearing—which is also dependent upon the steel backing—is greater than the solid aluminum at elevated operating temperatures. Experience has shown that steel-backed bearings can be designed to permit a stable mechanical fit over a considerable range of operating temperature, not only for similar but also for dissimilar mating components, as in the case of steel-backed bearings in aluminum crankcases.

In general, steel-backed aluminum bearings have proved to be particularly applicable in installations requiring thin wall bearings. Here the steel backing supplies the necessary yield strength to resist deformation under heavy-duty load conditions. Where bearing temperatures are very high and would cause solid aluminum bearings to exceed their yield strength and affect mechanical stability, the steel-backed aluminum bearings are also suitable.

Two fabricating methods are presently being used for steel-backed aluminum bearings. In the procedure developed by the Al-Fin Corp., steel tubes (plain carbon or alloy steel, depending on its application) are cut to desired lengths in automatic machines. The aluminum bearing alloy is then cast against the prepared steel surface. Depending on the application, the aluminum alloy can be placed on one or both sides of the steel backing and on the ends, if desired. The shells with the aluminum lining are subsequently machined and used as rounds or they are split for manufacture of bearing halfs. A similar procedure is followed for bushings and flanged bearings. (An article on the Al-Fin process in general appeared in MATERIALS & METHODS for October, 1945, page 1090.)

In the method employed by P. R. Mallory & Co., the aluminum bearing material is bonded to the steel backing in sheet or strip form. The bearings are then formed from the flat stock by any of the usual metal forming processes and machined to the desired dimensions. Bearing halfs, split round bushings, and any other bearing shape which can be formed from sheet, can be fabricated. Either one or both sides of the bushing can be covered by the bearing material.

In conclusion, it must be emphasized that the place of aluminum alloy bearings in the heavy-duty bearing field has not as yet been completely defined. Only when the study of their performance under actual service conditions is completed can a final appraisal be made. However, there is no doubt that aluminum alloys as bearing materials have a bright future and that the months to come will see continued development of their possibilities.

Heat Treatment and Stabilization of High Carbon Stainless Steels

by H. E. BOYER, *Chief Metallurgist* and H. C. MILLER, *Ass't. Metallurgist, American Bosch Corp.*

ALTHOUGH WE HAVE DONE a great deal of research work in the heat treatment of several types of martensitic stainless steels, the text of this paper deals entirely with Type 440C, which is the 1.00% carbon and 17.00% chromium grade with 0.50% molybdenum. Our goal in the development of heat treatments for this steel has been not only to obtain maximum hardness and wear resistance, but to develop a high resistance to corrosion, maximum toughness and dimensional stability, which is necessary in the manufacture of precision parts.

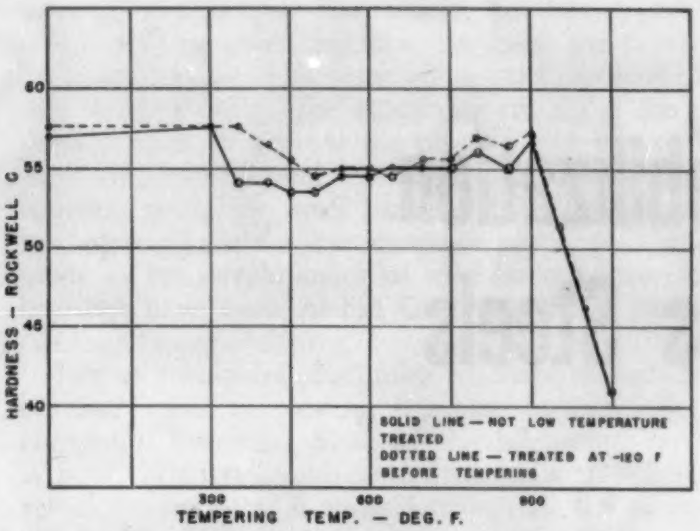
It has long been known that a high alloy such as Type 440C stainless retains high percentages of gamma phase after being cooled from the austenitizing temperature. This condition not only prevents maximum hardness from being obtained, but also leaves the heat treated parts in a state of dimensional instability. This can frequently cause difficulty after short periods of service. Our experience has shown us that it is usually advantageous to use austenitizing temperatures somewhat higher than have been recommended. By the use of higher austenitizing temperatures a greater percentage of carbide is dissolved in the austenite, thus resulting in a higher initial hardness, as well as a higher secondary hardness. Experience has proved that such practice causes a higher percentage of austenite to be retained, but by employing the use of low temperature treatment immediately after the quench, a great deal of this gamma phase is transformed.

The authors used 2-in. x 0.575-in. test specimens for all the heat treatments and tests. The results of these tests are shown by the charts and photomicrographs. These test pieces were all austenitized in a Sentry high temperature furnace using diamond blocks for atmosphere. Tempering was done in a standard Leeds & Northrup Homo furnace, and the low temperature operations were carried out in a standard "Deepfreeze" unit using air as a medium rather than any liquid. All of the methods used in the tests are entirely practical and can be duplicated in any heat treating department. The authors used a highly reducing atmosphere for the austenitizing operation, although it is not absolutely necessary because test pieces austenitized in an oxidizing atmosphere showed full hardness with little evidence of scale or decarburization. When possible, however, it is advantageous to use a neutral or reducing atmosphere in order that cleaner surfaces on the work may be obtained.

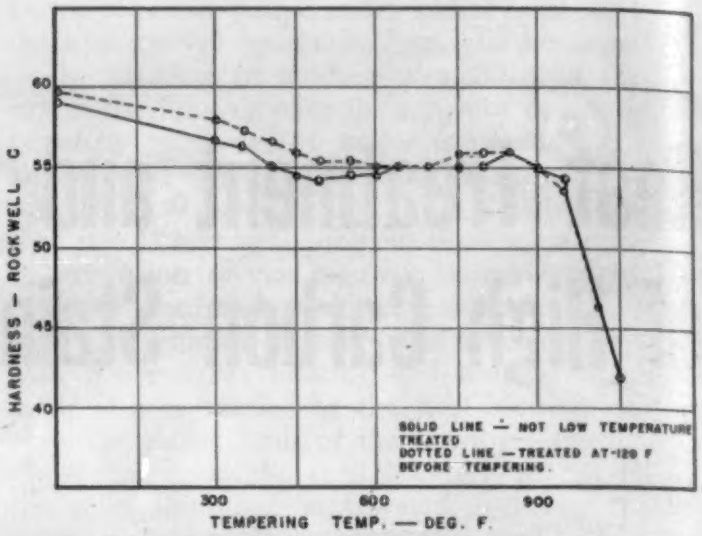
All measurements made in order to show the amounts of existing austenite were made by using the core loss principle, which merely takes advantage of the magnetic and nonmagnetic properties of the alpha and gamma phases, respectively.

Charts numbered one to ten inclusive show the hardness values that can be obtained from different austenitizing temperatures, using oil or air quenching. The effect of the low temperature treatment used immedately after the quench is also shown on each of these charts. As might be expected, it is evident from these charts that as the austenitizing temperature is increased the hardness obtained from the as quenched pieces is also increased. It can be seen that in most cases the speciments quenched in oil show slightly higher hardness values throughout the range than those cooled in still air. It also may be observed that Type 440C stainless, as in the case of most high alloys, possesses marked secondary hardening characteristics, which is proven by exploring the tempering range up to and including 1050 F for each of the five selected austenitizing temperatures. It is quite noticeable that in all cases the peak of the secondary hardness is relatively sharp. After this peak is reached the drop in hardness is extremely rapid. The peak of the secondary hardness for an austenitizing temperature of 1800 F may be ob-

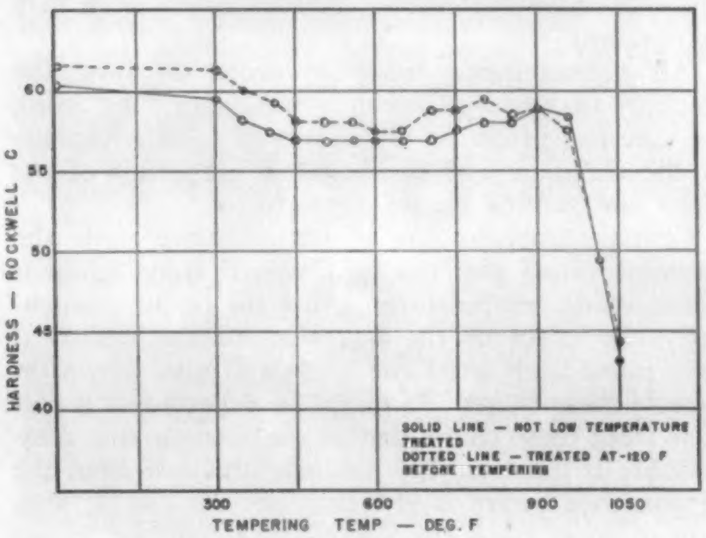
Here are the results of exhaustive tests on Type 440C stainless steel to determine proper heating, cooling and low temperature treatments.



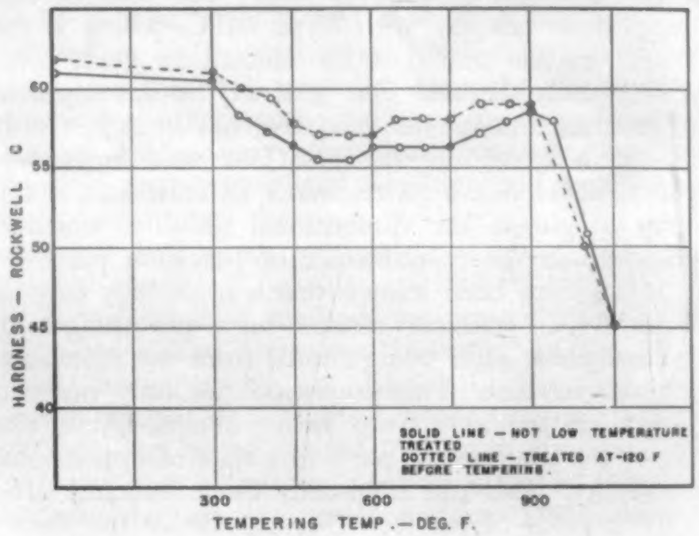
Austenitized at 1800 F, cooled in air and tempered as shown.



Austenitized at 1800 F, oil quenched and tempered as shown.



Austenitized at 1900 F, cooled in air and tempered as shown.



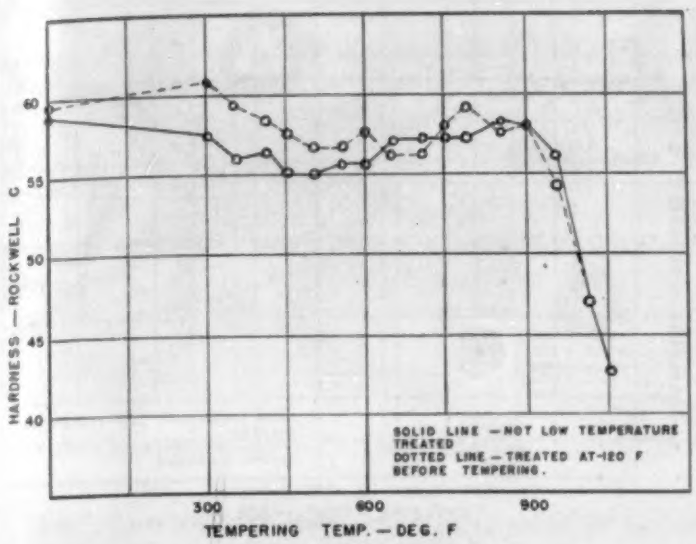
Austenitized at 1900 F, oil quenched and tempered as shown.

tained by tempering at about 850 F. When the austenitizing temperature of 2000 F is used, the peak of the secondary hardness will be found by tempering at 900 F. As is logical to expect, the effects of low temperature treatment, shown on the charts by the broken line, are much more noticeable as the austenitizing temperature is increased. This merely proves that the temperature range over which martensite forms is lowered and that the location of this range is a function of the austenitizing temperature which causes greater or lesser percentages of carbide to be dissolved in the austenite.

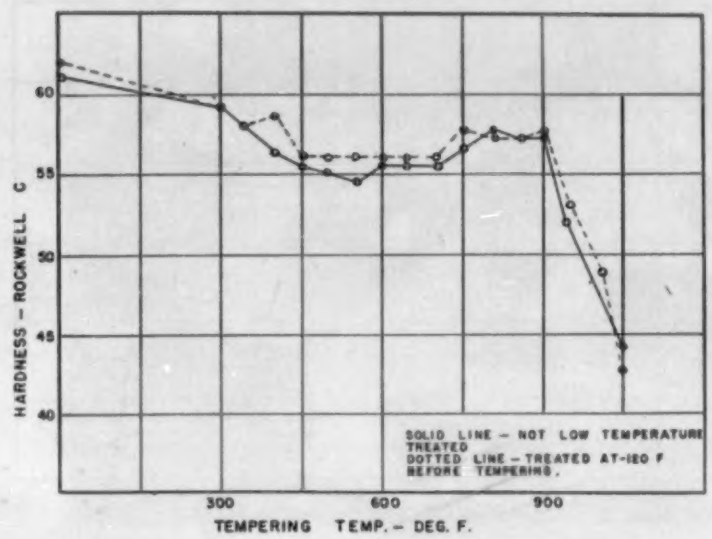
Photomicrographs in Figs. 15 and 16 show the structures of specimens after air cooling from 1800 F and 2000 F, respectively. Both of these specimens were electrolytically polished, etched in ferric chloride and photographed at 2150X. The variation in carbide solution as well as grain growth is obvious.

To obtain more data on this type of steel we austenitized test specimens over a very wide temperature range (1800 to 2000 F inclusive) in 50-deg. steps, the main purpose being to reach a temperature to result in nearly 100% carbide solution.

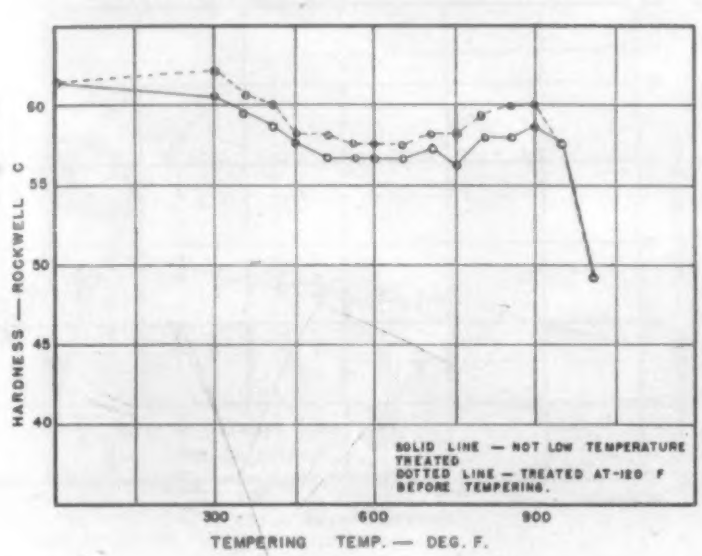
Fig. 11 is a chart showing the percentage of austenite retained after quenching from the various austenitizing temperatures over this 400-deg. temperature range, as well as the amount that can be transformed by treating at −120 F and subsequent tempering at 900 F, which is the temperature assumed to show maximum secondary hardening properties. No further structural changes were found to take place in these specimens after the low temperature treatment and one draw or temper to 900 F. It is always our practice, however, to use a double tempering operation in order to temper the newly formed martensite. It was found impossible to affect any further transformation of the remaining austenite by the use of repeated tempering operations or low temperature treatments. Specimens austenitized at 2150 F or higher were found to be 100% austenitic after the quench. Low temperature treatment and subsequent tempering caused a transformation of only about 3% of the total volume. Such findings are well proven by the photomicrograph in



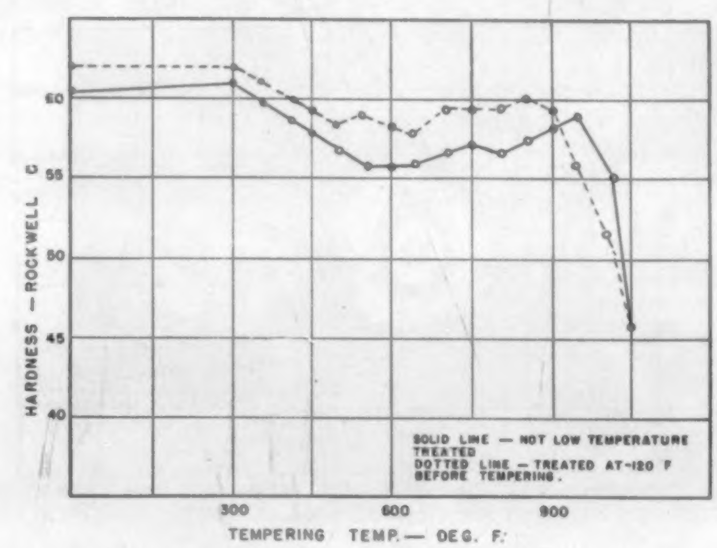
Austenitized at 1850 F, cooled in air and tempered as shown.



Austenitized at 1850 F, oil quenched and tempered as shown.



Austenitized at 1950 F, cooled in air and tempered as shown.



Austenitized at 1950 F, oil quenched and tempered as shown.

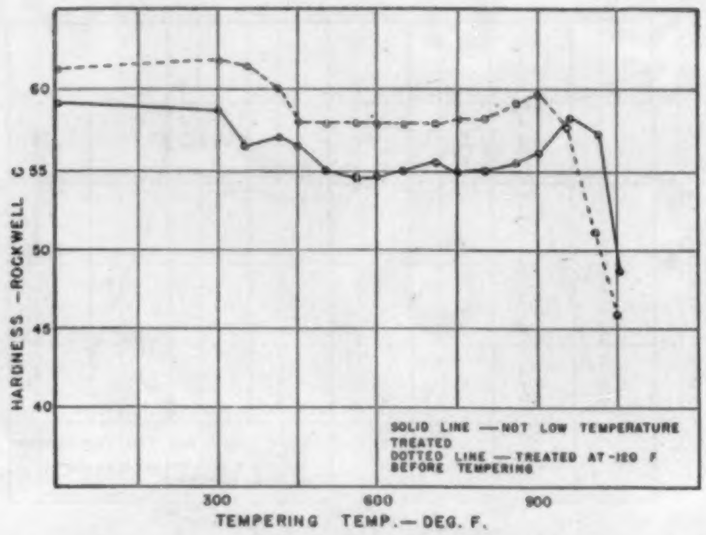
Fig. 17. This shows the structure of a specimen austenitized at 2200 F, cooled to −120 F, and double tempered at 900 F. This specimen was also electrolytically polished, etched in ferric chloride and photographed at 2150X. The very small amount of transformation product at the grain boundaries is obvious.

The chart shown in Fig. 12 is similar to Fig. 11 and requires but little explanation. The difference is merely in the sequence of operations. In the case of Fig. 12, specimens were tempered at 900 F immediately after quenching, then subjected to −120 F, which was then followed by retempering at 900 F. As shown in previous work, the specimens were found to undergo no further structural changes by repeated low temperature or tempering treatments though the lines on Fig. 12 do show a somewhat different pattern. This further proves that if low temperature treatment is used its maximum value can be obtained only by using it immediately after quenching.

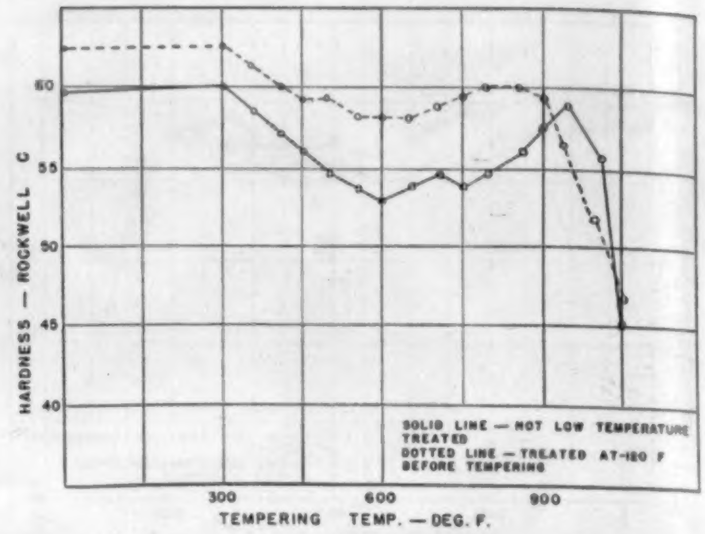
As indicated in Fig. 12, the specimens austenitized at 2050 F behaved in a seemingly peculiar manner. Specimens austenitized at 2050 F show that a greater net amount of transformation was affected by the low temperature treatment and the second temper than in the case of the specimens austenitized at 2000 F. This data was rechecked a number of times, but results were found to be the same in each case.

While it is generally agreed that impact testing on highly hardened steels is likely to give erratic results, so that true characteristics are not revealed, we have found by using a large number of specimens that much can be learned.

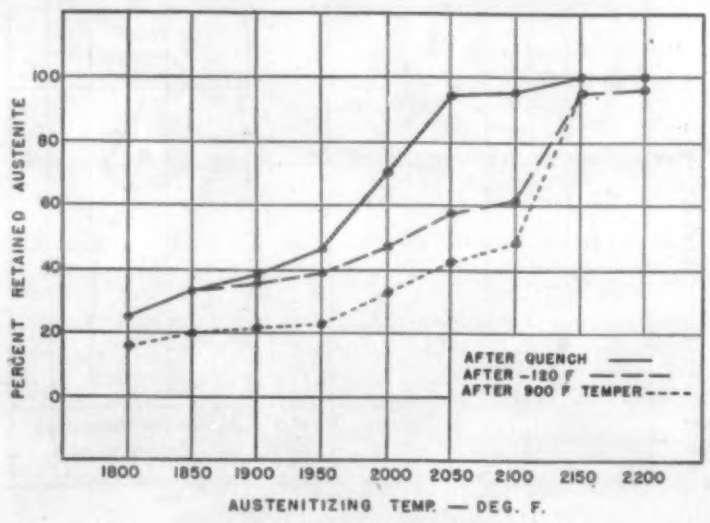
Fig. 13 shows impact results (unnotched Izod) which were obtained on specimens air cooled from 1950 F which we regard as the optimum austenitizing temperature, at least for most purposes. Specimens were impact tested in the as-quenched condition as well as after quenching and subjecting to −120 F. Other specimens austenitized in the same manner were tempered in 50-deg. steps from 300 to 1050 F inclusive. Many specimens were used in order to obtain the data shown in this chart so that



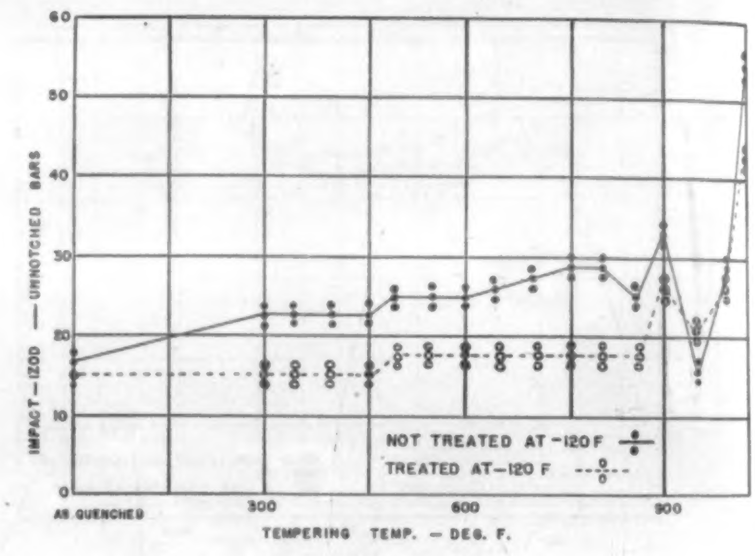
Austenitized at 2000 F, cooled in air and tempered as shown.



Austenitized at 2000 F, oil quenched and tempered as shown.



Effect of austenitizing temperature on retention of austenite.

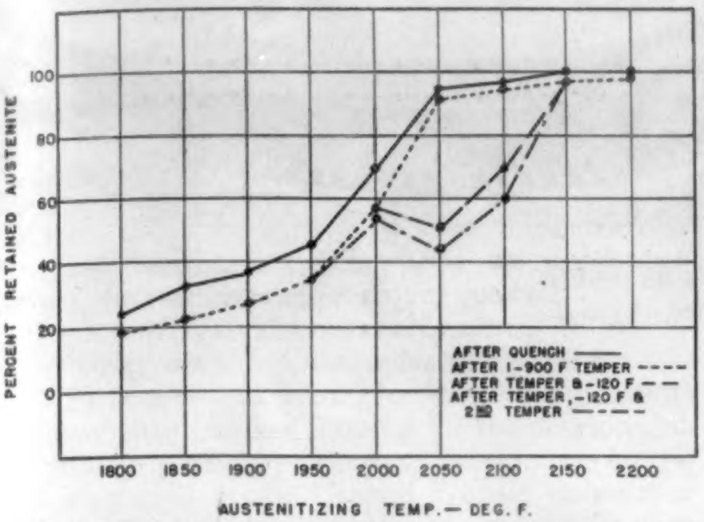


Austenitized at 1950 F, cooled in air and tempered as shown.

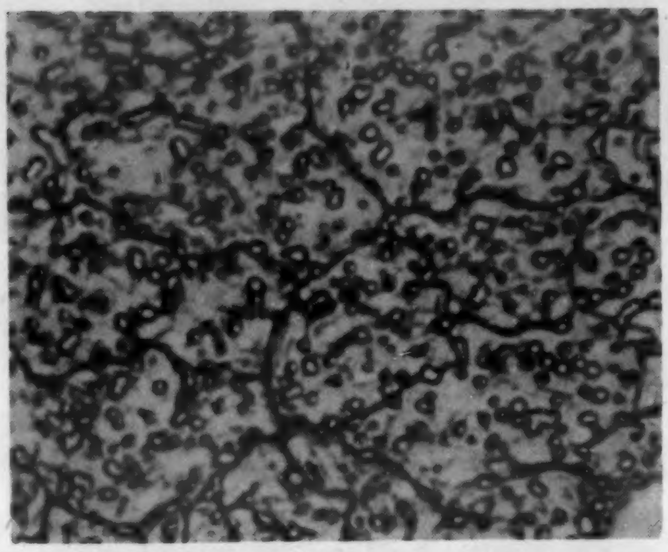
the lines show the average impact value while the dots or circles show the range. The solid line shows the impact value for specimens which had not been low temperature treated while the broken line represents the average value for specimens which were subjected to −120 F after still air quenching. This steel obviously has a lower impact value when subjected to the low temperature treatment which might be expected since these specimens were harder and showed a higher percentage of transformation to martensite. It is also important to note that the relatively sharp secondary hardness peak which is obtained by tempering at 900 F is immediately followed by a sharp drop in impact value, thus suggesting that temper brittleness is present in specimens tempered at 950 F for the above austenitizing temperature. After tempering at 1000 F the impact value rises rapidly as the hardness decreases.

At least as a matter of academic interest and possibly to assist in answering a rather old question some data on the necessary time for parts to be held at low temperature are also included, as shown in Fig. 14. From the data shown in Fig. 11 it is obvious that the amount of transformation accomplished by the −120 F was about 22% of the total volume in the case of specimens austenitized at 2000 F. We therefore selected this autenitizing temperature to obtain the data shown in Fig. 14. A large group of test specimens were austenitized at 2000 F, air cooled to room temperature and immediately subjected to a medium of air at −120 F. We then removed the specimens at 5-min. intervals, measuring the amount of transformation after they had again assumed room temperature. This was continued until the length of time was found after which no further transformation took place. It may be readily observed that no further transformation took place on specimens 2-in. x 0.575-in. after ½ hr. at −120 F, which means that as soon as the temperature is reached no further transformation will take place at that given temperature. Prolonged holding at low temperature or repeated cycles at low temperature seem to be of absolutely no value.

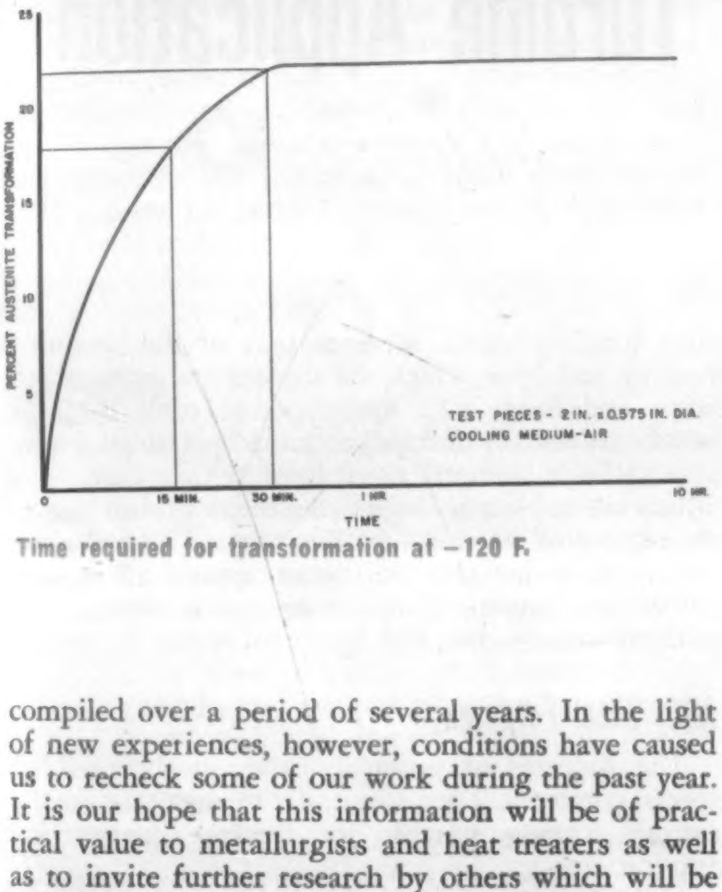
The data given in this paper have actually been



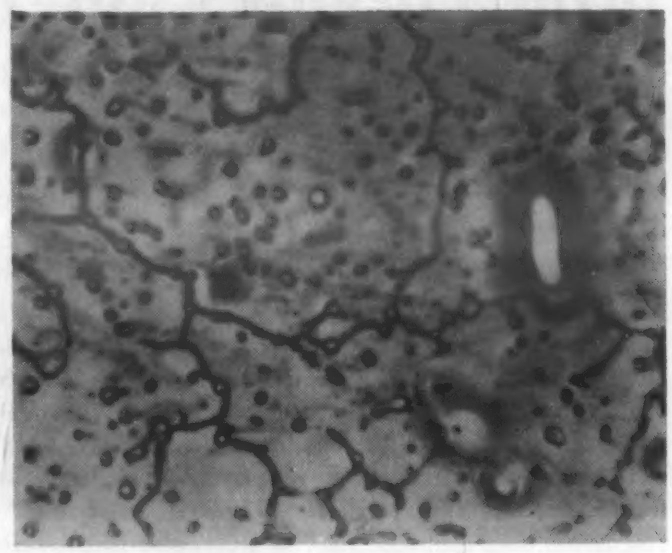
Effect of austenitizing temperature on retention of austenite.



Structure of test specimen after cooling from 1800 F (2150 X).



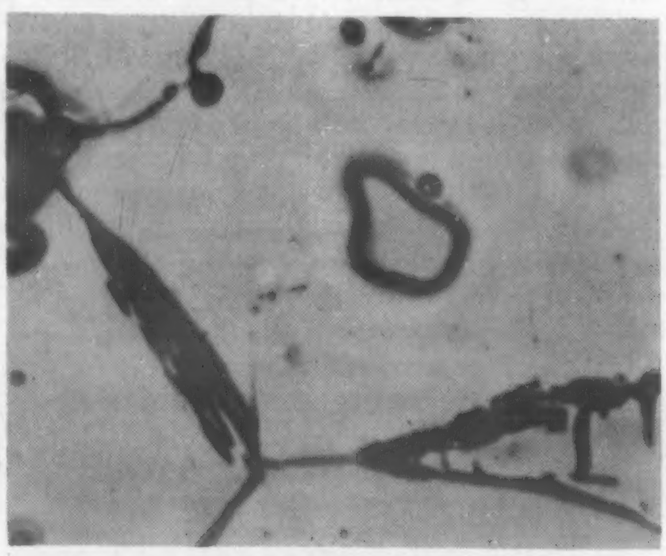
Time required for transformation at −120 F.



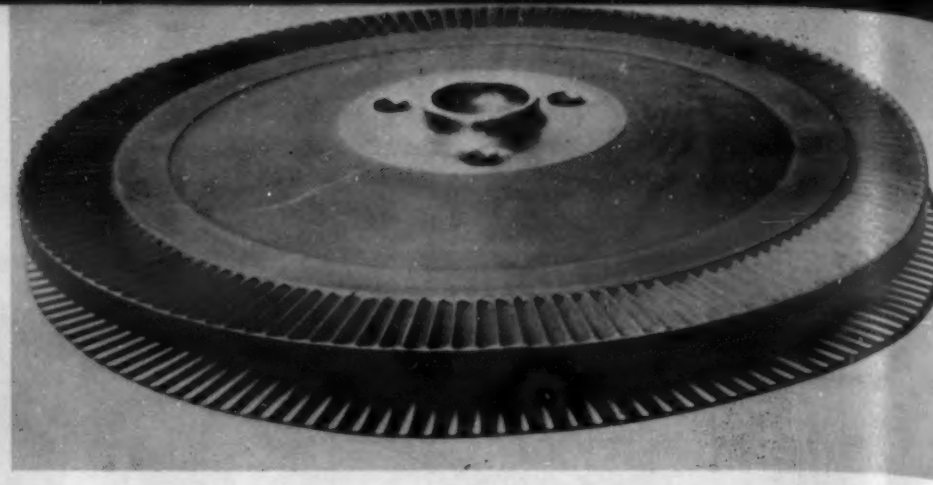
Structure of test specimen after cooling from 2000 F (2150 X).

compiled over a period of several years. In the light of new experiences, however, conditions have caused us to recheck some of our work during the past year. It is our hope that this information will be of practical value to metallurgists and heat treaters as well as to invite further research by others which will be of value to everyone using high alloy steels.

From the information given in this paper the metallurgist or heat treater should be able to select heat treatments to fit particular engineering demands. For most purposes, however, involving the use of this steel we recommend that Type 440C stainless be austenitized at 1950 F in a protective atmosphere, quenched in still air, cooled in a medium of air to −120 F and double tempered at 900 F. Although our experience with the use of a high temperature salt bath for the austenitizing operation is limited, we do know that such a method is very successful. Such a treatment as described above will produce work that is consistently 57 to 60 Rockwell C, will possess good resistance to wear, dimensional stability and a high resistance to most forms of corrosion.



Structure of a specimen austenitized at 2200 F, cooled to −120 F and double tempered at 900 F (2150 X).



At the left is a drop-forged disk "as forged." To its right is the same disk after machining and with blading attached.

Drop Forgings for Gas Turbine Application

by CARL I. SCHWEIZER, *Chief Metallurgist, The Steel Improvement & Forge Company, Cleveland, Ohio*

THE HISTORY OF THE EVOLUTION of the gas turbine has been well reviewed in many articles written recently, and will not be repeated in this one. Suffice to say that the underlying principle is old and sound, and that its ultimate economical application as a prime mover is much closer to realization than it was just prior to the war. It remains for the engineers and metallurgists to push the improvement of design and material only a little farther and the result will be the widespread use of a new competitive engine.

The author recognizes that in the gas turbine (and in its jet engine counterpart) there are, and probably always will be, some forged parts, some cast parts, and some parts formed of sheet metals. This article is not written for the purpose of comparing different methods of manufacture, but rather to discuss the drop forging of those gas turbine parts which have been specified as, and ordered as, drop forgings.

Three general classifications will cover most of the forgings used in these engines. They are (1) alloy steel forgings which serve as part of the structural bracing and upon which the stresses are more or less static and fixed; (2) disk type, or rotor forgings, which are usually formed of some special alloy possessing high strength at elevated temperatures, and which are subject to high centrifugal stresses due to their speed of rotation (see Fig. 1); and (3) blade or bucket forgings, also usually of special alloys, and subject to complex vibratory stresses as well as centrifugal stresses (see Fig. 2).

Gas turbines and jet engines required forged parts that imposed new concepts of accuracy and control in the nation's drop forge shops.

Alloy Steel Forgings

The forgings of group 1 (alloy steel) need no special comment. They are similar to any other quality aircraft forging suitable for fuselage construction applications.

Disk and rotor forgings served to initiate the industry into the manufacture of custom made forgings from special materials. Production manufacturing of disks originated at the time that the aircraft engine turbosuperchargers began to be built in quantity. The turbo rotors are closely enough related to gas turbine rotors to warrant some discussion. Turbo disks, to which suitable blading was attached, operated by the expanding of hot exhaust gases through their blading. The temperatures of the disks often reached 1200 F. It was necessary, therefore, to employ alloys in which high strength and creep resistance at 1200 F could be developed, and which were resistant to oxidation, or corrosion by hot gases. The alloys also had to be machinable.

The most promising materials from the start appeared to be the high chromium-high nickel austenitic

stainlesses. Modifications in the form of stabilizer additions, additions of strong carbide-forming elements, increased nickel content, and the addition of molybdenum for creep resistance eventually produced more satisfactory alloys.

Table I shows the analyses of some of the materials that have been or are being used for turbosupercharger, gas turbine, and jet engine rotors.

The centrifugal stresses encountered on turbosupercharger discs (on the order of 28,000 rpm. at 1200 F) necessitated in some cases the use of further treatment than just hot forming for the development of optimum physical properties. Considering the 16-25-6 alloy used in the General Electric turbosupercharger, the practice consists of hot forging, or blocking, to the approximate finished dimension, and then re-forging below the temperature of recrystallization, thereby cold working the material and increasing its strength.

Although gas turbines and jet engines (which have been developed subsequent to the introduction of the turbosupercharger) supply their own hot gases instead of utilizing exhaust gases from another engine, the disk requirements are very similar. This fact lead most of the first manufacturers of gas turbines and jet engines to use the existing turbo alloys as the starting point for further development work on even higher temperature alloys. At the present time 16-25-6 and 19-9 DL are the most universally used rotor materials for gas turbines.

Disk Forgings

Two types of disk forgings are in current use. First is the "pancake" type of upset forging in which the finished disk faces are parallel and require considerable machining. Die preparation costs on this type of forging are comparatively low. Second is the "contour" upset forging in which the metal grain flow follows the cross sectional contour of the finished shape. The contour type requires much less machining. Both the pancake and contour types can be either hot forged, or hot and cold forged, depending on the alloy being used and the engine manufacturer's desires. The contour forging is usually preferred both for economy of machining and also because of the advantage of proper fiber direction.

There are several manufacturing problems involved in contour forging where hot and cold forging are required. The original bars as received from the alloy manufacturer are surface ground and must have no harmful center segregations. After blocking, the semi-finished forgings are inspected for surface defects which, if present, must be removed before the final low temperature forging operation. Die wear is comparatively rapid during the latter stages of forging. The alloys under discussion are much stiffer at hot forging temperatures than ordinary alloy steels, and their plasticity at the finishing temperatures is even less. The inherent stiffness of these alloys and the resulting die wear are better appreciated if it is remembered that the prime requirement of the disks in service is that they do not deform at elevated temperatures.

The final processing consists of relieving residual forging stresses by a heat treatment at around 1200 F. The hardness resulting from the hot and cold forging and stress relief ranges from 241 to 311 Brinell. To prevent any great variations in hardness within a single forging, a proper design balance between blocking and finishing dies must be maintained.

An adequate upset ratio (ratio of length of forging multiple to the cross sectional size) is necessary to insure that the resulting grain fiber will best enhance the physical properties of the finished disk.

Some engineers prefer disks hot forged only (no subsequent low temperature work). In such cases 19-9 DL is the material most frequently used. As hot forged this alloy does not develop the hardnesses shown by the low-temperature-forged 16-25-6 or 19-9 DL materials, but its properties at the higher service temperatures are comparable. Among several other good disk materials not quite so universally used are S-590, Inconel X, and N-155 (see Table I). Best working properties on these alloys are developed not by cold working, but by solution treatment and age

Table I—Rotor Materials in Current Use

Alloy Developed By	Alloy Designation	Analysis						
		C	Ni	Cr	Mo	W	Co	Others
Timken Roller Bearing Co.	16-25-6	0.12 max.	24.0/27.0	15. /17.5	5.5 /7.0	—	—	N_2 0.10/0.20
Universal-Cyclops Steel	19-9 DL	0.26/0.36	8.0/10.0	18.0/22.0	1. /1.5	1./1.5	—	Cb 0.20/0.60 Ti 0.20/0.60
Universal-Cyclops Steel	19-9 W-Mo	0.08/0.12	8.0/10.0	18.0/22.0	0.20/0.50	1./1.5	—	Cb 0.20/0.60 Ti 0.20/0.60
*U. C. & C. Corp.	N-155	0.10/0.20	18.0/22.0	18.0/22.0	2.5 /3.5	2.0/3.0	18.0/22.0	Cb 0.75/1.25 N_2 0.10/0.20
Allegheny-Ludlum Steel	S-590**	0.43	19.42	20.88	4.33	3.93	19.31	Cb 3.92
International Nickel Co.	Inconel X	0.08 max.	71.0/75.0	14.0/16.0	Ti plus Al plus Cb equals 4.0%			

** Union Carbide & Carbon Corp.*　　*** Typical analysis*

hardening. Although this heat treatment makes their processing somewhat more cumbersome, the high temperature properties developed by these materials are certainly worthy of consideration.

Blades and Buckets

Parts falling within the group 3 classification (compressor blades and turbine buckets) are, by their design characteristics, the most difficult types to produce by forging.

As the building of experimental jet engines and aircraft gas turbines progressed, it was realized that the number of blades required would be tremendous. The quantities of compressor blades and turbine buckets necessary to construct certain models, including replacements, runs into four figures. The forging industry was asked to enter into this production for two purposes. First, its production, added to that of the casting industry, would come closer to furnishing the necessary number of blades. Second, it was thought that forged blades might offer some engineering or metallurgical advantage over cast blades. To date no specific material nor method of manufacture for blading has been universally accepted as standard.

Blades are used in great quantities in the axial flow compressor component of the gas turbine engine. This compressor, although it operates at the same speed as the turbine which drives it, is not subjected to elevated temperature conditions. This factor has allowed the design engineers a wider choice of compressor blade materials. They may be either cast or forged of almost any number of materials including carbon and alloy steels, the turbine quality stainlesses, aluminum, etc. At the Steel Improvement & Forge Co. compressor blades are forged of Type 403 stainless, with the final forging temperature controlled to produce a blade hardness of 32 to 42 Rockwell C. The engine manufacturer finishes the forgings by milling a dovetail at the root, and then grinds the leading and trailing edges slightly to their final shape, and polishes the blade.

One of the underlying principles of the gas turbine is that its efficiency increases as the temperature of the products of combustion increases. This fact, when translated into the field of practicality, indicates that certain zones in the gas turbine should be able to operate at sustained temperatures in excess of 1300 F for the life of the engine. This requirement governed the choice of gas turbine bucket materials. Operating conditions are similar to disk operating conditions, except that the buckets attain a somewhat higher temperature in service, and are more complexly stressed. Therefore, alloy materials of suitable strength at even higher temperatures were needed. In the case of the turbine buckets, which constitute the driven mechanism of the turbine, actual operating temperatures range between 1200 F and 1400 F, with the ultimate aim even higher for the sake of efficiency.

Complex operating stresses and thin cross sections have in general precluded the use of the same materials for buckets as is used in disks. It would be extremely difficult to use the hot-and-cold forging procedure on sections of this size. The materials most widely used for turbine buckets are Vitallium, or Haynes-Stellite #21 (always used in the cast condition), Hastelloy B, S-816, and K-42-B. Among some of the other bucket materials which are used less universally are N-155, 16-25-6, and Inconel X. Test results on the latter alloys indicate that their high temperature properties are commendable. See Table II for analyses of bucket materials.

Both bucket and disc alloy development is being carried on with speed and enthusiasm by practically all of the steel companies, many of the nonferrous alloy manufacturers, and engine producers.

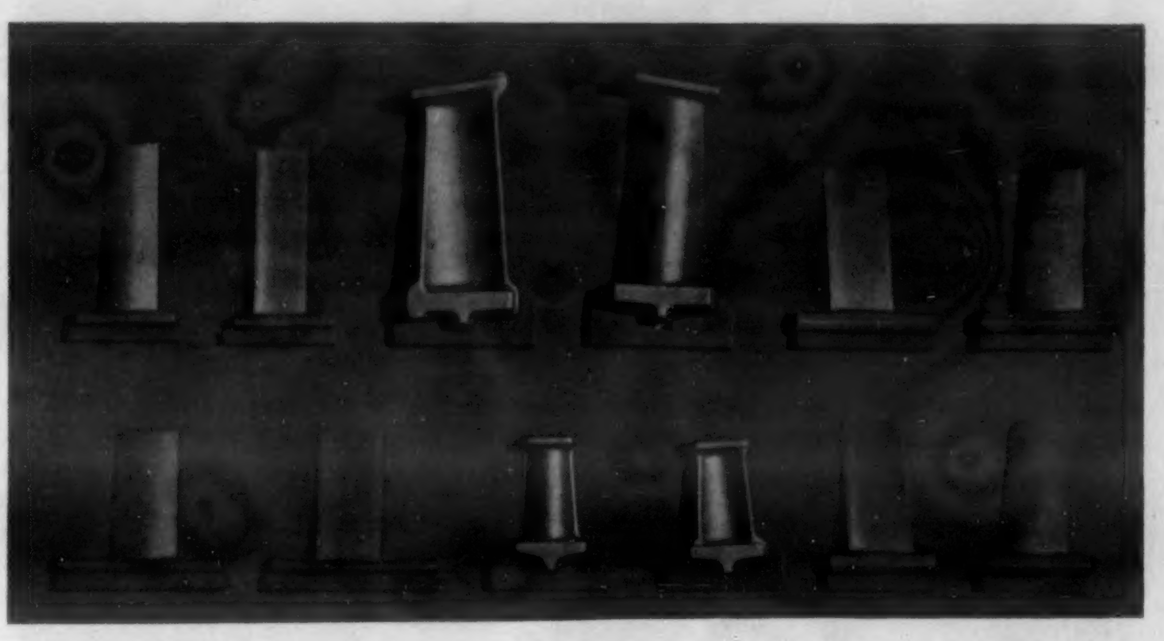
Forging Requires Many Operations

The actual forging of the above materials into thin sections requires a great number of operations. Forging temperature is rapidly lost after one to three hammer blows are struck, and a series of reheatings must be made as the forging progresses. These alloys are quite prone to rupture during the initial breakdown operation and must be hammered with fairly light

Table II—Blading Materials for Forged Buckets

Alloy Developed By	Alloy Designation	Analysis						
		C	Ni	Cr	Mo	W	Co	Others
*U. C. & C. Corp. & Haynes-Stellite	Hastelloy B	0.02/0.12	62.5/68.5	—	26.0/30.0	—	—	Va 0.25/0.50
Allegheny-Ludlum Steel	S-816	0.30/0.45	18.0/22.0	18.0/22.0	3.0/5.0	3.5/6.0	38 min.	Cb 2.5/4.0
*U. C. & C. Corp.	N-155	0.10/0.20	18.0/22.0	18.0/22.0	2.5/3.5	2.0/3.0	18.0/22.0	Cb 0.75/1.25 N_2 0.10/0.20
International Nickel Co.	Inconel X	0.08 max.	71.0/75.0	14.0/16.0	Ti plus Al plus Cb equals 4.0%			
Timken Roller Bearing Co.	16-25-6	0.12 max.	24.0/27.0	15.0/17.5	5.5/7.0	—	—	N_2 0.10/0.20
Westinghouse Electric Corp.	K-42-B	Information not available at date of publication						

* *Union Carbide & Carbon Corp.*



The central group of four is comprised of gas turbine buckets of S-816. The other forgings are compressor blades of Type 403 stainless steel.

blows. As the work assumes a thinner, flatter shape, and the hammer blow is distributed over a larger area, heavier blows may be struck without danger of cracking. On many of the blade designs as the final stages of forging are reached the metal is so thin that only one blow per heating is possible.

From the beginning the most difficult problem encountered in the manufacture of forgings of this general type was to hold them to the desired shape and thickness tolerances. These tolerances (as little as ± 0.010 in., -0 in. on sections ranging from 0.30-in. to 0.020-in. in thickness) were so much narrower than forging shops had been used to working to that a whole new attitude had to be accepted. Die impressions had to be sunk to within 0.002 in.; unorthodox die materials had to be used at unorthodox hardnesses to minimize die wear and loss of shape; new forging furnace installations had to be provided to insure against excessive scaling, decarburizing, or carburizing during the many heatings required on a particular forging before it reached its finished size; improved die swabbing compounds were needed to prevent forgings from sticking in the dies; "process grinding" between forging operations proved beneficial; constant laboratory supervision of all forging processes, atmosphere control, and heat treating was adopted.

The combination and use of the above innovations eventually enabled the Steel Improvement & Forge Co. to produce buckets and blades of acceptable size and shape. (It was apparent from the start that it was the purpose of the engine manufacturers to do as little machining or grinding as possible on these parts and that the nearest thing to perfection that could be supplied by blade producers would not be too good. The ending of the war emergency has loosened the reins somewhat, and the trend among some of the companies interested in the peacetime production of gas turbines is toward accepting forgings to less stringent thickness and shape tolerances. Under the latter plan, forgings are much cheaper to produce, and part of the resultant savings can be used to accurately machine-finish the blades.)

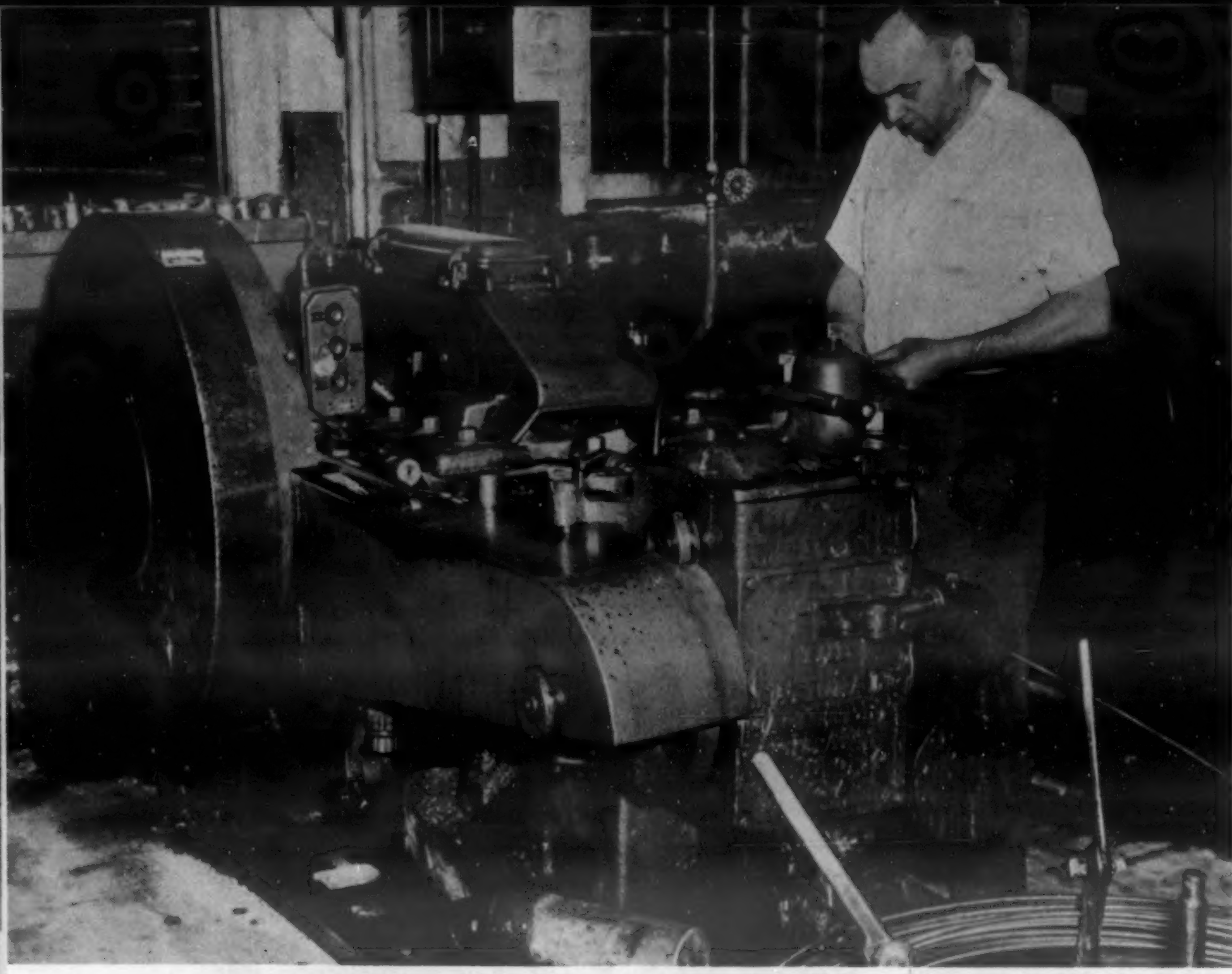
As was mentioned in a previous paragraph, extreme difficulty would be encountered if it were endeavored to obtain physical properties by cold working forgings of the shape and size of blades. Therefore, the physicals which are to be ultimately obtained are usually developed by heat treatment only. Most of the bucket materials discussed in the preceding paragraphs have their best properties developed through solution treating and age hardening. Table III lists the hardness ranges normally specified for blades and buckets made of various alloys, and indicates the type of heat treatment used to obtain the hardnesses.

Stress to rupture data have purposely been omitted as being superfluous under the subject of discussion. Information of this nature, covering physical and mechanical properties, may be obtained from the respective alloy manufacturers.

Table III—Usual Hardnesses of Forged Buckets and Blades

Alloy Designation	Application	Hardness	Method of Obtaining
Hastelloy B	Turbine buckets	93 to 103 R/b	Stabilize 24 hr. and 1900 F
S-816	Turbine buckets	26 to 33 R/c	Solution treat and age harden
N-155	Turbine buckets	245 to 300 BHN	Solution treat and age harden
Inconel X	Turbine buckets	280 to 330 BHN	Solution treat and age harden
16-25-6	Turbine buckets	200 to 300 BHN	Hot forge and stress relieve*
K-42-B	Turbine buckets	Information not available	at date of publication
AISI-403	Compressor blades	32 to 42 R/c	Control forging temperature

* *Finishing temperature can be varied to obtain desired hardness*



Shown in operation here is a 5/16-in. double stroke solid die cold header. (Courtesy: Corbin Screw Div.)

Dies for Cold Headers

by H. HANCOCK PALMER, *Development Engineer, General Mills, Inc.**

RECENT STRIDES MADE BY THE cold heading process are so tremendous, and the importance of the process to the technological progress of the metal fabricating industry is growing so rapidly, that the problems attendant upon the method must and will be overcome.

Cold heading is approaching screw machining in accuracy. It has natural advantages of higher production speeds, lower scrap losses, and better physical properties in the part manufactured. It will continue to press for lower tool costs, greater accuracy, and more intricate work in its attempt to compete for business which has hitherto been a screw machine monopoly.

* *Mr. Palmer gathered experience in the problems discussed here while with the Corbin Screw Div. of the American Hardware Corp.*

Once the other major cost factors of the cold heading process are established, attention will be focussed on the die—its initial cost, its upkeep, and its failures with resulting losses in production. This does not

With the increase in application of cold heading it is important that the peculiar problems of dies for this process be fully understood.

mean to say that the other tools never cause trouble—far from it! Punches, quills, and knockout pins all have their bad moments; but the dies, with their more exacting heat treating procedures, closer tolerances, and more severe operating conditions, require far more effort and patience for satisfactory results.

The header die problem has its managerial aspects, but this article will remain mostly technical, skeptically assuming the Utopian State wherein management's anxiety for economy and a smooth production schedule is supplemented by a full recognition of the problem and the will to attack it objectively and methodically.

In specifying die dimensions, heat treating procedures, and raw material, the engineer must have access to certain information which does not appear in the handbooks, and he must apply it shrewdly. For example, when wire is cold headed, the blank "springs back" or swells slightly after it is ejected from the die. To allow for this tendency in his die design, the engineer must have not only the design of the blank and the physical properties of the specified material, but also accumulated performance data. This last item gives him a basis from which to estimate the amount of spring-back to be expected in a specific situation. It might be possible to calculate spring-back from existing spring formulae; but the best means of obtaining the necessary data still appears to be close checking of the dies, blanks and materials in regular production.

In choosing a die steel the engineer will do well to use a top grade of straight 0.90 to 1.00% carbon steel of medium hardenability until all variables are properly controlled. Experimenting with a thousand and one grades and types of tool steel without evaluation controls will lead only to confusion and unwarranted—sometimes costly—conclusions. Heat treatment specifications should be worked out empirically by the engineer in close cooperation with the metallurgical and operating departments. Well-defined procedures should thus be established and religiously followed.

There is frequently much to gain by the intelligent use of different types of steel or of die design for some applications. For example, a fillister head die will usually function better with deeper than average hardening under the head. This can be obtained to only a limited extent by heat treatment; a better means is the use of a deeper hardening steel. Where extrusion is the principal function of the die and shock is at a minimum, carbide inserts and even solid carbide dies have made startling production records which more than justified their high initial cost. Tool steel inserts, though lacking most of the pre-stressed condition of the well-hardened solid die, often decrease unit die costs. As yet the increased finishing costs of high-speed steel inserts have rarely been justified, but much developmental work remains to be done in this promising field.

Making the Die

There are several objectives in the actual fabrication of the solid header die. The hole must be straight, round, and parallel with the outside surface within close limits; the hole surface must be as smooth as is consistent with the balance between die cost and die life; the hole size must be as specified and must be accurately gaged; and the die must be heat treated properly for maximum service. Concentricity of the hole, while important, is secondary to parallelism, as the die and punches will be lined up anyway in setting up the header.

The first step in the die making process is a thorough metallurgical inspection of samples cut from the centerless ground bar stock. Die steel can best be specified by its Jominy hardenability characteristics and structure, with strict limits on soundness and homogeneity.

After release by the laboratory, the approved bars are sliced into blanks with an abrasive cut-off wheel. The ends of the blank are usually hardened somewhat by this operation, but grinding *both* die faces to attain the desired blank length removes these hard ends and at the same time squares the blank.

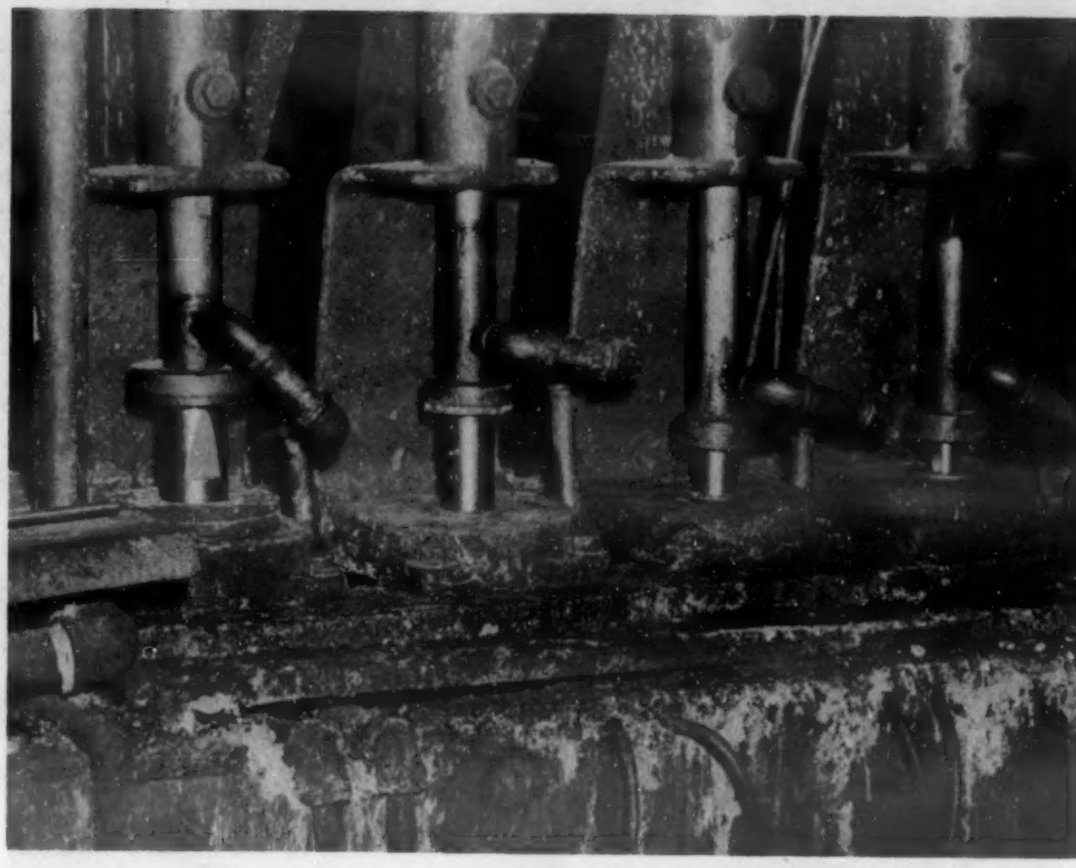
Next, the die blanks are slabbed deep enough to provide a secure seat for the die block set screw, yet not so deep as to materially weaken the die. The blanks are usually slabbed one at a time on a specially adapted milling machine, but there is no apparent reason why the operation could not be expedited by gang milling with a horizontal traverse table, or even by form shaping.

For the rough machining operation, a turret lathe or a handscrew machine of the #2 Browne & Sharpe type is preferable. The headstock should be supplied with stop collets for the dies, and the drill should be motorized. With this equipment the die blank can be quickly and accurately set up, and high drilling speeds can be used without changing machine speed between drilling and reaming. A true hole can be drilled and reamed all the way through from one end; and, if required, the die may be counterbored without altering its location in the slightest. The die is turned end for end in the collet for removal of the drilling burr, and for counterboring those double end dies which require it. With the exception of broaching vertical breather grooves into the larger fillister heads, further machining is not usually necessary before heat treatment.

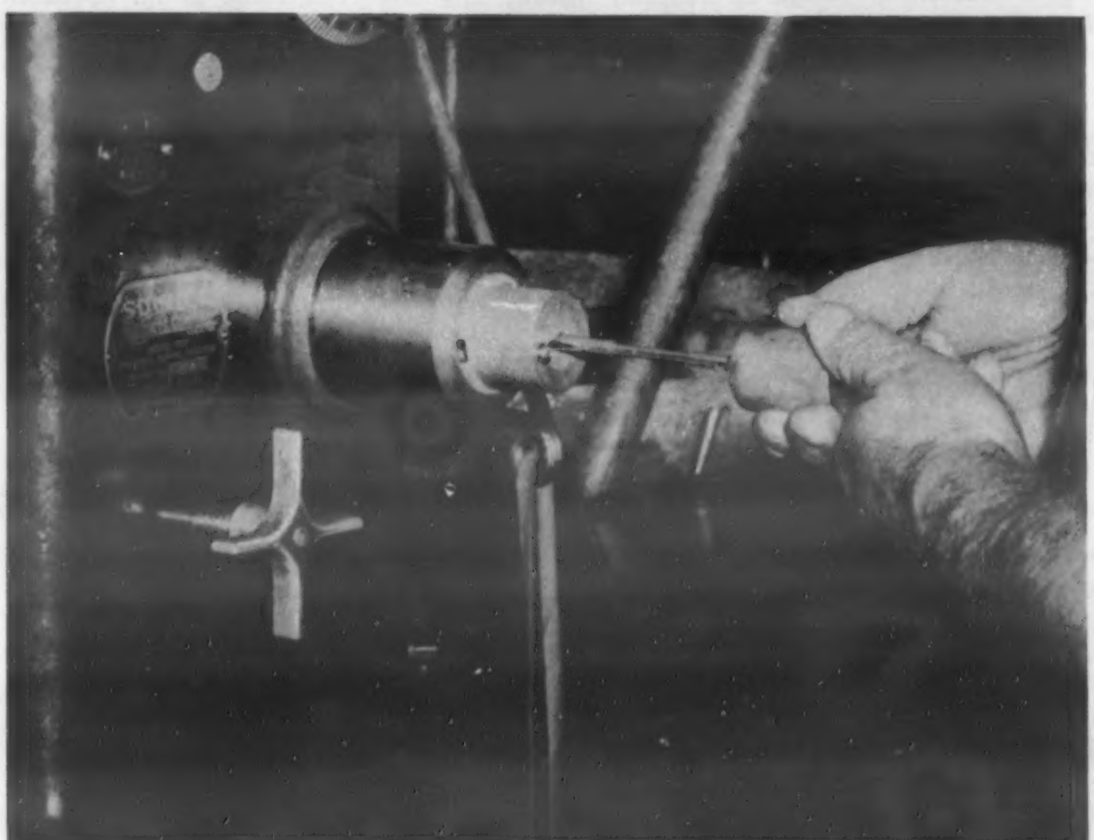
This rough machining operation is highly important. On it rests most of the responsibility for the degree to which the finished hole will be straight, parallel, and concentric with the outside of the die. High calibre, well maintained equipment is absolutely essential here, for an enormous amount of finish machining or care in setting up the header is required to wangle even mediocre production from a die which began life as a juvenile delinquent.

Inspection before heat treatment may be simple, but it must be thorough. A plug check will suffice for the hole size, as several thousandths must be left for finish machining. The die should also be spun on centers with an indicator near each end to check concentricity and parallelism.

Heat treating is, unfortunately, often thought of as the source of and panacea for all the ills of the die problem. Yet it is actually subject to closer control



This spout quenching fixture is for quenching header dies through the holes. (Courtesy: Corbin Screw Div.)

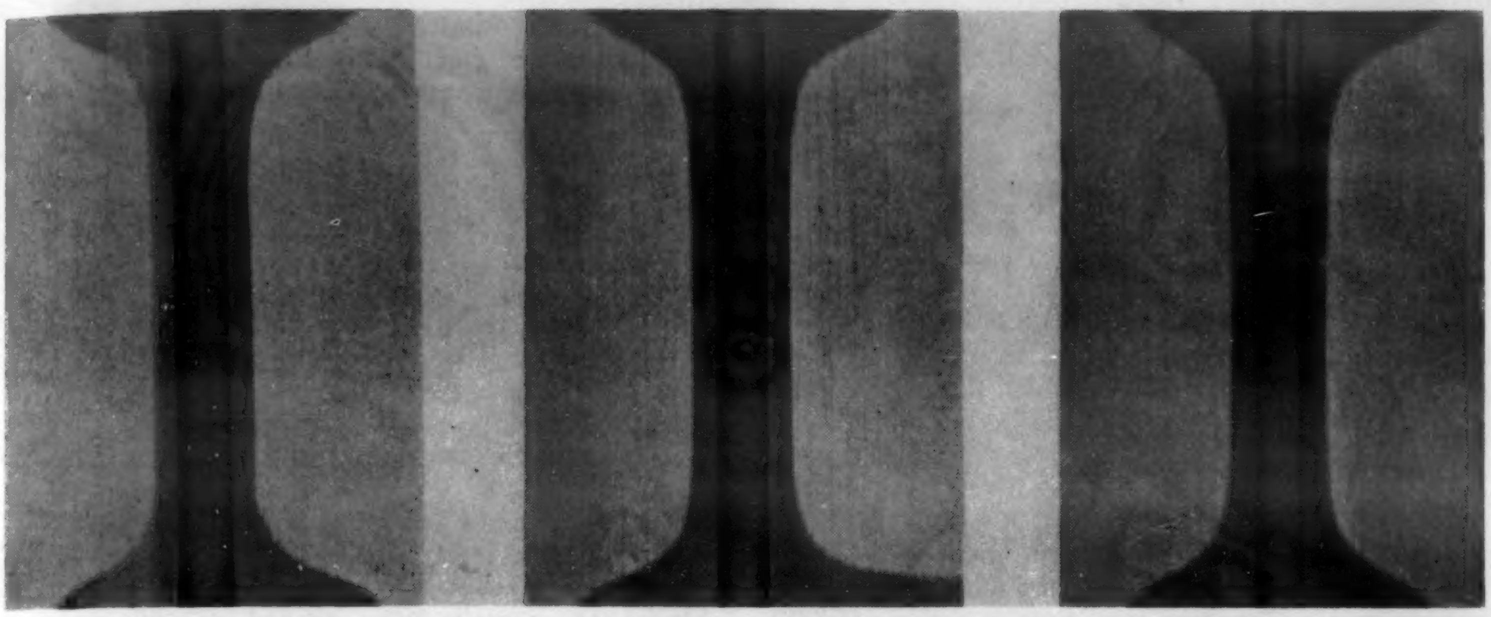


Finished size of header dies is attained by honing. (Courtesy: Corbin Screw Div.)

than that which is necessary for the other phases of die manufacture and use. Hardening specifications should call for a preheat at about 1200 F for a half hour or more before transfer to the hardening furnace. Hardening temperature and time at temperature depend entirely on the size of the die, the steel of which it is made, and the effect desired, and defy generalization. Preheat and hardening furnaces should both have atmospheres controlled slightly on the reducing side. Scale in the hole or on the faces is most obnoxious, whereas a thin decarburized skin will be removed in finish machining.

Small Dies Flush Quenched

Dies less than 2¼-in. in dia. should be flush quenched on special fixtures which force a stream of brine up through the hole, and which confine the



These header dies have been split, halved and etched to show the hardness pattern and flaws.

brine to the hole and to a portion of the die face around the hole, with splashing minimized. The temperature of the brine should be around 90 to 110 F. Pressure should be sufficient for rapid quenching, but not so great as to cause uneven quenching; probably something like 25 psi. "Spreaders" must be used at both the orifice and the receiving end of the fixtures to avoid the formation of steam pockets. Dies 2¼-in. or more in dia. should also be flush quenched, but with water on an under-water fixture, as the greater mass of the die cannot be cooled fast enough by quenching only through the hole.

Flush quenching is a must in modern hardening practice. With this technique a high hardness can be used where it is needed most, in the hole and on the central portion of each face; while this hard case is reinforced with a thick cushion of tougher steel, the hardness grading off rapidly to about 40 Rockwell C. In addition, compressive strains are set up in opposition to operational stresses, making far more strength available than the theoretical strength of the steel.

As soon as the outside of the die has cooled below a red heat, the die should be taken from the pneumatically operated fixture and the quench completed in oil. Dies should be left in the oil until they cool to 150 to 200 F; drained, and placed in the tempering furnace before they reach room temperature. As in hardening, so in tempering the temperatures vary with the steel and the desired hardness; but time at temperature must never be skimpy—an hour in a circulating air furnace is an absolute minimum for even a light load of small dies.

The dies are cleaned by sandblasting, though the faces will very likely also need a touch of emery before Rockwelling. The hardness must strike a balance between toughness and abrasion resistance; and the hardened case must be deep enough to prevent spalling, yet not so deep as to encourage splitting. Hardness should be in the range of 53 to 61 Rockwell C, and the hardened case should be 1/16-in. or more deep, with both qualities depending on the size and type of die.

After an informal hardness test by the heat treater, the dies go to tool inspection for an official Rockwell and a check for bell-mouth. Soft dies and mild cases of bell-mouth can be corrected by the heat treater, but *not* after the diemaker has run his finish reamer through the die. A re-hardened die is not likely to perform as well as its properly handled brother, however, and the value of such salvage is questionable.

From tool inspection the approved dies go to the die room for finishing. First, the barrel shape produced in hardening is corrected by centerless grinding. A die which retains this barrel condition may be hard to get into the die block, encouraging the header set-up man to hand grind the die with unpredictable consequences. Once in the block, such a die will rock no matter how tight the set screw may be, varying the alignment and appreciably shortening the life of the die.

Die Faces Ground

The die faces are also ground, removing scale or craze marks along with the bulge from hardening, and at the same time adjusting the depth of the shoulder, countersink, or counterboard hole, as the case may be. Face grinding must not be done too harshly. Heavy cuts set up strains which, unless they are relieved by a low temperature bake, will cause the die to fail early by chipping around the rim of the hole.

For the ensuing reaming operation, there seems to be little real choice between horizontal and vertical machines. Neatsfoot or lard oil should be used as a lubricant, and reamer speed should be very low, about 35 to 50 rpm. Reamers can be made of any good

brand of high carbon drill rod, hardened to the limit and tempered in boiling water only, so that the finished hardness is at least 66 Rockwell C. Better hole finish and longer reamer life have been obtained by some manufacturers from reamers made of so-called "fast finishing" tool steel drill rod. There has been some work done with nitrided high-speed steel and with carbide tipped reamers; but since, in reaming, red hardness and high machine speed are subordinate to edge retention and hole surface finish, neither development has seen much success as yet.

Die holes which are large enough should be honed to size. At least 0.002 in. should be left in the hole for this operation. Honing removes the lateral reamer tool marks, and the honed surface (ten micro-inches or better) gives a valuable increase in gaging accuracy and die life. Honing equipment will be developed for the smaller holes, but meantime a hand expansion lap should be used to take the last 0.0005 in. or more from the hole.

Tolerance on the diameter of the fillister or countersunk flat head is usually sufficient to eliminate the need for finish machining. A reaming or honing operation, however, while unnecessary for sizing, pays dividends in increased die life by lessening drag on the head of the blank when ejected, and by decreasing the accumulation of gunk in that portion of the die hole.

After finish machining, the dies must be most carefully inspected before release to the header department. First, hole size is checked; ideally by means of an air gage through most of the hole, and with an ordinary plug gage in the first 1/16 in. of each end of the hole. Either type gage can be used alone, but this combination will give the most reliable results. A simple depth plug gage is good enough for the counterbored hole of a fillister head, but all countersunk flat head and shoulder dies should be checked by making a lead print and measuring it on a comparator. The surface of the larger die holes can be checked by instrument, but at present the smaller holes can only be checked by eye. All dies should also be rechecked for concentricity and parallelism.

Using the Die

Having struggled through the tortuous and exacting process of fabrication, the dies are now delivered to the header room. Here the human element reaches its peak. The best die can stand or fall on the header set-up, and this factor depends largely on the set-up man's judgement. The cut-off blade must be correctly sharpened and set so that the wire slug is not bent; the feed fingers must center the wire slug with respect to the die hole; the punches must be accurately aligned with the die; the various steps in the cycle must be properly timed; the knockout pin must fit just right in the die hole; the die must be firmly held by the die block; the wire lubricant, if one is used, must be applied with discretion; and all adjustments must be closely watched to minimize the period during which the header can operate out of adjustment. The flash should be kept as thin as possible if a shaving operation is to follow heading. However, the thinner the flash the greater the shock on the die and punch and the shorter their life, so it is up to the operator to keep said flash near the maximum limit.

A wire lubricant, another important factor, may be needed for coated as well as bright wires. Occasionally, serious epidemics of die failures on some particular job can be materially alleviated by simply adding or changing lubricants. It is not possible to generalize on lubricant specifications; the type and amount required depend on the blank design, the wire analysis, the wire surface condition, and the machine speed.

Naturally, the mechanical condition of the header has a considerable influence on die life. The best die will not stand up very long in a decrepit machine which is tight in the loose joints and loose in the tight ones. Loose or out of line die and punch blocks are especially to be avoided.

The physical properties of the wire to be headed are just as important to header tool life as are machining characteristics of bar stock to screw machine tools. Inevitably the finished product is the primary consideration; but often either the raw material or subsequent heat treating practices can be so changed, at little or no added cost, as to greatly increase die life. Tensile and yield strengths, elongation, hardness, structure, chemical analysis, and surface condition all have their effect on die life, and should be thoughtfully specified and rigidly inspected by the manufacturer.

Attacking the Problem

The keynote of the whole attack on the solid header die problem must be coordinated control of all variables, from raw die steel and wire to the headed blank. Constant and competent inspection is vital to the retention of high standards throughout the process. But inspection alone is not enough. To attain full effectiveness, the inspectors' findings must flow to a central point for tabulation and interpretation. At this point also, the production performance of the dies must be correlated with their fabrication history.

A quality control system performs two major functions. First, it keeps little troubles little. As danger signs appear in the inspection records of any phase of the process, that phase can be singled out and brought up to standard before serious trouble develops. Second, when a batch of dies appears to be performing poorly, the control system provides the trouble-shooter with a complete history of the dies. This information aids definite determination of the cause of failure, and tremendously expedites removal of same.

Striking improvement in solid header dies cannot be expected until all phases of the cold heading process are brought up to peak efficiency. Even then, results cannot be accurately evaluated without quality control. A systematic attack upon the problem, however, coupled with sufficient follow-through, can in most cases effect economies which greatly outweigh any additional engineering or inspection expense.

MATERIALS & METHODS MANUAL

19

This is another in a series of Manuals on engineering materials and processing methods, published at periodic intervals as special sections in Materials & Methods. Each of them is intended to be a compressed handbook on its particular subject and to be packed with useful reference data on the characteristics of certain materials or metal forms or with essential principles, best procedures and operating data for performing specific metalworking processes.

Plastic Laminates — as Engineering Materials

by Kenneth Rose,

Engineering Editor, MATERIALS & METHODS

Plastic laminates offer one more weapon for the materials engineer in his ever-continuing battle to overcome rising labor costs. Their characteristics, including light weight, high dielectric strength, low water absorption and resistance to attack by most acids, mild alkalies and chemical solvents, make them serious contenders against metals for many structural applications. Most of the laminates can be supplied in the common metal forms such as sheets, rods and tubes as well as in the shape of preforms. This manual is devoted to a discussion of the three types of plastic laminates — high pressure, low pressure and composites — and to the machining characteristics of these materials.

Contents

Materials & Methods, September 1946

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Introduction

When those materials grouped under the term "plastics" are referred to as glamour materials, the thought usually conveyed is of beautifully molded objects in pastel colors, or of transparent, glasslike toilet ware, or of thin films or coatings magically water-resistant. These types are all of importance to the materials engineer, no less than to the sales manager, for the engineer must recognize and evaluate the possibilities of plastic bottle caps as against those of metal, just as he must determine the load-bearing capacity of aircraft flooring of a plastic-cored sandwich as against plywood. However, the engineer concerned with processing materials in his own plant will be more directly interested in a group of plastics scarcely in the glamour class—the high-strength, lightweight, water-resistant, heat-resistant plastics, reinforced with a fibrous material, and usually referred to as the laminates.

The laminates are essentially structural and engineering materials. They possess strength properties that approach, and in some cases exceed, those of the metals. Their thermal stability is sufficient to permit their use under ordinary conditions, whereas some of the more glamourous plastics will show excessive creep when exposed to a hot sun. They can be fabricated by a number of methods, and are capable of improvement of physical properties by proper formulation of the material and by certain methods of design. High electrical resistance is another of their properties of interest to the engineer.

While the plastics manufacturer usually thinks of the group as the plastics laminates, the term "reinforced plastics" is gaining favor. "Laminates" refers to multilayered materials other than plastics, and the plastics manufacturer includes some of these, not primarily plastic, such as resin-bonded plywood, within his group. Reinforced plastics can also be those molded resins containing chopped fibrous filler, but the term is here used to mean laminated plastics, including sandwich materials, in which the resin is a considerable part of the total finished material. For the materials engineer, resin-bonded plywood is primarily a wood material.

General Selection Factors

An important consideration to the engineer thinking of plastics as structural materials is the fact that the reinforced plastics are supplied for stock in the same forms as the metals and most other materials of construction that he buys, *i.e.*, in sheets, tubes and rods. Fabricating possibilities frequently parallel those available for metals.

Plastics in this group are classed among the general utility resins, and the addition of the laminating material gives them greatly improved shock and impact resistance as specific properties. Even when formed at high pressure, and with a comparatively heavy laminating material, they are substantially lighter than the lightest structural metals. This lightness is often a deciding advantage in connection with such fields as aircraft parts fabrication.

High electrical resistivity is a property that accounts for a considerable part of the total quantity of heat-setting plastics used. Production of electrical insulators and other electrical goods was one of the first applications of the phenol-formaldehyde resins produced more than 30 years ago. Maintenance of resistivity in service is closely associated with high resistance to absorption of moisture, and this is another valuable property of the group. Resistance to attack by most acids, and by mild alkalies, as well as by most chemical solvents, is an important advantage over most of the metals. These properties will be discussed in detail in connection with the types of structural plastics.

Among the factors that limit the use of plastics are cost, restricted formability, lack of hardness and hardenability, generally low strength, and low resistance to deterioration by heat. In competition with metals, the strength properties of even the structural plastics are rather low. Working temperatures are below 300 F for even the more heat-resistant types; they are heat-resistant only by comparison with other plastics.

As with all the other factors, generalizations about cost of plastics must be made cautiously. Steel may sell at 3 to 7 cents per lb., aluminum at 15 to 30 cents, magnesium at 20 to 35 cents, and plastics at 14 cents to $6.00 per lb. Costs per cubic in. will approach one another more closely. Costs per unit of strength, or of some other measure of performance, could be calculated only for a specific item, and would not be broadly adaptable. It could be safely predicted, however, that the gap between steel and plastics would be widened.

An additional cost item is the cost of fabricating. Here again steel has a decided advantage for many parts, since high speed press operations are among the most economical forming procedures. With the laminated plastics forming operations require slow-moving machinery, and holding at heat and pressure during the curing time. An exception must be noted in the case of contact laminating, but this is a specialized low-pressure method not adaptable to a wide variety of parts.

As an indication of the relative values of strength per unit area, cost per unit volume, and cost per unit strength of some of the familiar structural plastics as compared with competing metals, graphs are shown with these figures for comparison. Strength per unit area is simply the tensile strength of the material in pounds per sq. in. Cost per unit volume is the price per cubic in. of material, and permits an evaluation of the relative "bulk" of material bought. This is of importance, because materials are usually used on a bulk basis, although bought by weight. The final chart, showing cost per unit strength, is an attempt to reduce the comparisons to a "cost per performance" basis. It is upon this basis that materials are evaluated in design, although the evaluation is seldom done analytically.

Structural plastics are, in general, about one-half as heavy as aluminum. With tensile strengths of about 6,000 to 12,000 psi. for the general purpose phenolics, they have something less than half the strength of most aluminum alloys. By using thicknesses slightly greater than would be chosen with aluminum, however, sheets or panels can be made in plastics with a saving of weight, and with a gain in rigidity due to the thicker section.

Another advantage is exemplified in the manufacture of plastic hulls for small boats. Here the competing material is usually wood or plywood. In forming the hull of wood, the individual planks must be cut carefully, fitted by hand, and fastened by hand labor also. With plywood construction the material costs are higher than with lumber, but labor costs are sharply reduced since the material is handled in large sheets of laminated wood, or as thin sheets of wood laminated to finished form in the building process. When using plastics material, costs rise sharply again—probably to twice that of the plywood—but a boat hull can be produced within about half an hour. Labor costs are again reduced. With the rapidly increasing cost of labor this becomes an increasingly important item, and may be a decisive factor. Plastic hulls are being offered at prices quite close to those quoted for plywood construction of the same size.

The weight factor does not enter into the above example with the same force as in those cases in which a plastic competes with a metal. The reasons for this are, first, that plywood is not sold by weight, so that a cost-per-pound comparison would be roundabout, and, second, that the weights of plywood and plastic are too similar to offer a substantial advantage.

Structural plastics, as distinguished from plastics primarily used for gadgets, decorative purposes, and the like, are usually load-carrying members of a structure or machine. They may become small timing gears, aircraft flooring, motor coach side wall, prefabricated house partitions, aircraft wing control surfaces, underwater bearings and many similar applications. The range in size from a timing gear to a 22-ft. boat, each molded in one operation, is in itself an indication of the versatility of structural plastics. Aircraft parts are designed to

inimum safe weights, and the use of stics for such vital structures as wing d rudder surfaces points up their value lightweight materials.

ypes of Laminates

With such wide range of applications, rtain of the structural plastics are more itable for some of these purposes than e others. The plastics under consideration ay be divided into groups according to eir method of preparation, and these oups will correspond to general properties at in turn determine their use. A preliminary selection may be made in this way deciding upon the general type of structural plastic required to provide a given set properties.

These types are:

High Pressure Laminates—These plastics ake use of paper, cotton, asbestos, or glass ber as the laminating material, and are rmed at high pressures—generally 1000 si. or higher. They are denser than plastics rmed at lower pressures, are most resistant to moisture, and so have better electrical properties. Because of the molding rocedures used, they are limited to simple rms. Special grades can be postformed, d so make possible a wider choice of rms.

A smoother surface is obtained by high ressure laminating, and so a product of mproved appearance. Decorative effects n be produced also.

Low Pressure Laminates—Because lower ressures per unit area are required for ese resins, larger sizes can be produced. his is the type chosen for molding plastic oats in one piece. Because only one side is ressed against the die, only one surface ill be quite smooth. Lower density results from the lower pressures used. Although pressures are influenced by size of the piece and by other factors, they are generally about 100 psi.

Low pressure laminating would be the first choice of types when a molded product is desired. When the higher mechanical strength, chemical resistance, or electrical resistivity of the high pressure laminates are required, parts may sometimes be postformed by low pressure, and high-pressure molded to final form.

Sandwich Laminates—As comparatively new materials, these are among the most promising of the structural plastics. They consist of facing materials and a lightweight core. Various combinations are possible, so that the composite may be made to meet a wide range of design conditions. One or both surfaces may be of metal, usually aluminum, or of plastic, plywood, etc. Core materials of various densities are available.

Lightness of weight is one of the most general characteristics of the sandwich or composite laminates. As the core materials are usually porous so that their densities may be low, they are frequently good insulators also. Finally, because the cross-section of the composite is such that the surfaces develop their full compression strength while the lightweight core maintains rigidity, the composites have quite high strength-weight ratios. This makes them especially desirable as materials of construction in aircraft. Their high cost is the chief deterrent to their use.

The composites, because of their nature, are difficult to fabricate to any but simple forms. So far they have found their widest use as flat sheets, cut to shape.

Laminated plastic materials, in the form of shells, are being used for sink and cabinet tops. Those shown here were designed and made of Formica by Calplasti Corp., Los Angeles. (Courtesy: Formica Insulation Co.)

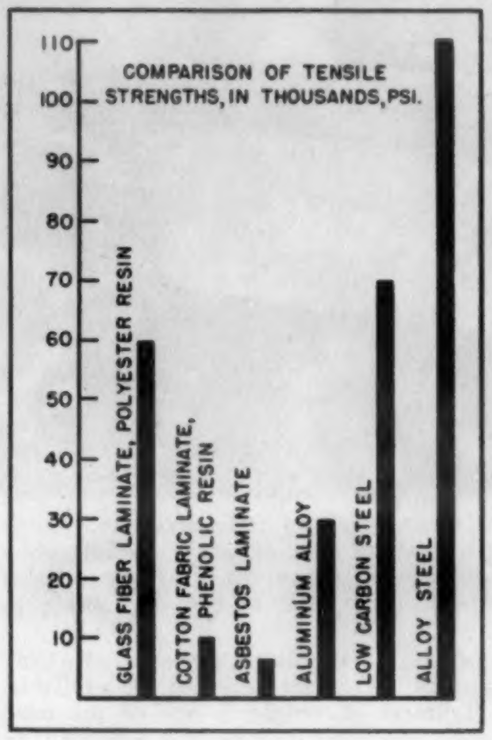
High Pressure Laminates

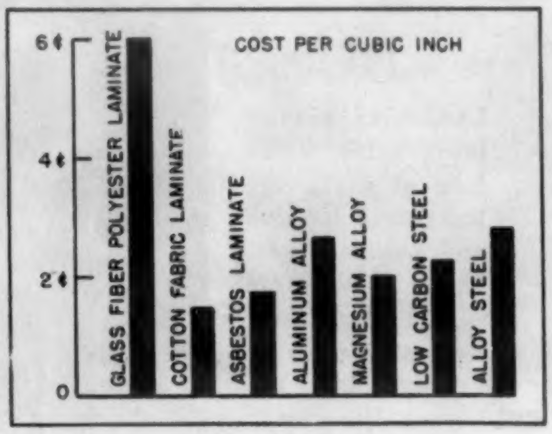
The high pressure laminates are those esin-filler combinations in which the filler s impregnated with a solution of the plastic, iled or wound into sheets, rods, tubes, or ther forms, and cured under heat and ressure of about 1000 psi. Within this imple formula considerable variation is ossible, so that the high pressure laminates ffer the greatest latitude in control of physical properties of any of the plastics. The ype of filler can be varied; its composition nd quality changed to give the properties esired. The resin may afford variation by election of basic materials of different types, y varying the catalysts used, or by the use f various modifying agents. After selection f all constituents the properties of the finished laminate can be varied by changing he proportions of resin and filler, or by hanges in the degree of cure, hardness, penetration of resin, or finish. Temperature nd pressure for curing are subject to manipulation, especially the pressure, which may vary from 500 to 1500 psi. or higher.

The filler, which contributes a large part of the tensile strength and impact resistance of these laminates, may consist of cotton fibers, used as fabric, either in sheets or chopped, or as batts of paralleled fiber, paper, either rag or wood stock; glass filaments, as fabric or in batts; asbestos fibers, as fabric or as paper; or wood veneers. The types of fillers, with the variables in their properties or method of use that affect the physical properties of the laminate, are shown in the following table:

Physical Properties of Laminates

Filler Material	Type Used	Form Used	Variables
Cotton Fibers	Woven fabric Unwoven	Sheets or rolls Chopped Batts, fibers paralleled	Strength, count, add weave of cloth
Paper	Wood fiber—kraft, mischerlich, alpha Rag	Sheets or rolls Chopped	Type, strength, weight, and thickness of paper
Glass Filaments	Woven fabric Unwoven	Sheets or rolls Fibers or batts	Strength of filament, weave of cloth or orientation of filament
Asbestos Fibers	Woven fabric Paper	Sheets or rolls	Strength, purity of fiber
Wood Veneers		Thin sheets	Type of wood, thickness of veneer, orientation of plies





Of the resins used, phenol-formaldehyde is the most common. Melamine-formaldehyde, urea-formaldehyde, and analine-formaldehyde are also serviceable, while some of the polyesters and new colorless phenols are entering the field. The resin is used as a solution or dispersion in solvents, or in water. The viscosity of the resin-liquid varnish determines the ease of penetration of the filler; water dispersions give a more ready penetration than the organic solvents.

The method of impregnating the filler with the resin may involve immersion of the filler in a varnish bath, or liquid bearing the resin can be applied by rollers, sprays, etc. When the immersion method is used, the web of filler is fed through a tank containing the resin in its liquid medium, and drawn out through squeeze rolls or over a doctor blade to remove excess liquid. If the resin is to be applied to the filler without immersion, a roller may pick up the resin from the bath and transfer it to the web of filler moving in contact with the roll, or transfer roll can be used to apply the solution. Sprays positioned so as to reach the entire surface of the web of filler can be used to impregnate the fabric or mat with the resin-bearing solution—a method frequently used when the laminating material is used as a mat, and drawing over a roller or a doctor blade is not advisable.

When glass fabric is to be used as the filler, it is customary to remove the lubricant applied during the weaving of this filament. Passing the fabric through an oven, usually gas-fired, held at about 700 F, will burn off the coating.

The resin content used can vary considerably, depending upon the applications for which the finished laminate is intended, and upon the type of filler used. With fabric laminates the resin content will be about 50 to 60%. With one type of glass fiber, the "swirled" filament web, resin content may be as low as 5%. Impregnation of most types of webs will take place in several stages, and several methods of application of the resin may be used successively.

A drying operation follows the impregnating process. In this step the solvent is removed, and the resin is also partially polymerized. The drying ovens, horizontal or vertical, are heated by steam coils to permit careful limitation of the heating. The web leaves the oven in a state that permits it to be rolled without showing a tendency to stick together.

The resin is said to be in the *A* stage before drying. In this stage it is soluble, fusible, and the impregnated filler is readily formable. After drying, the resin has been somewhat modified by the heat applied, and is said to be in the *B* stage. It is still fusible enough to permit laminating into a sheet or other form, but polymerization has started. When finally laid up into a succession of plies for sheets, tubes, rods, or other forms, and treated at high pressure and elevated temperature, the resin passes into the final—or *C* stage, in which it is infusible, insoluble, and practically unformable except by machining or similar process. This is the fully cured condition.

In the *B* stage the laminate presents wide possibilities for forming. The method of laying up the plies, whether placing the sheets one on top of another in the same position or whether placing alternating plies at 45-deg. to the principal direction of the weave, largely determines directional strength properties of the finished laminate. The 45-deg. lay-up affords practically equidirectional tensile strength. Postforming makes possible the production of shapes more complicated than the simple standard forms. When the forms to be produced are too complicated to be prepared by postforming, the impregnated filler may be macerated and molded much like molding powder.

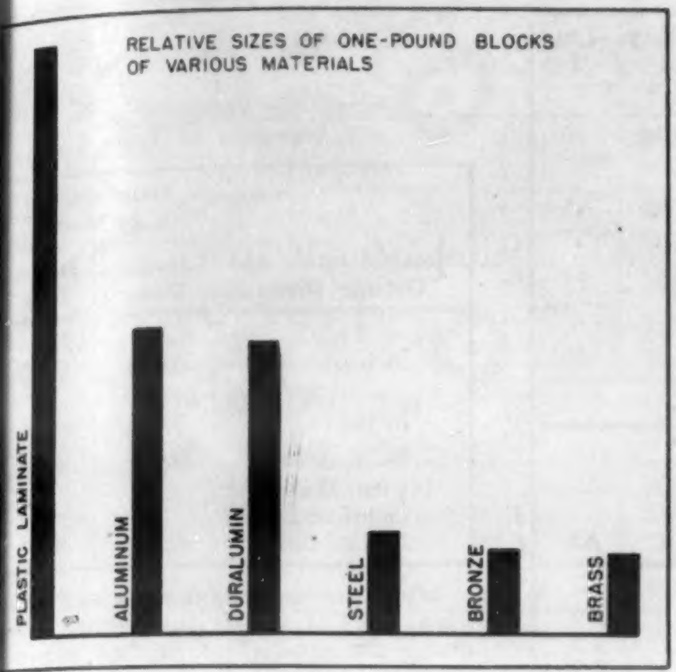
The final stage in the preparation of the standard forms consists of completing the polymerization by applying heat and pressure while forming the piece. When making sheets the impregnated material is cut into pieces of the proper length, piled layer on layer until it reaches a height that will give the required thickness in the finished laminate. The stack is compressed in a hydraulic press at about 1000 to 1500 psi., while the plates are heated to about 300 F. Highly polished plates will produce a smooth, glassy surface. Plates can be sand-blasted or otherwise treated to give varied surface textures. A decorative pattern can be applied, or wood effects can be created. The finished sheet may be rubbed to a satin finish if desired.

When tubes are to be produced, the laminating material is wound over a mandrel the size of the inside diameter of the tube, and either baked in an oven to produce a rolled tube, or formed in a mold under heat and pressure if a molded tube is desired. Rods are made similarly, but the mandrel used is small, and is removed before the laminate is placed in the mold.

Various special shapes are produced by cutting the filler to a desired pattern and curing between platens or in a mold.

Additional flexibility in design is given the plastics laminates by the process of postforming. Postforming grades are incompletely polymerized, and so can be subjected to a limited amount of forming, at either high or low pressures, to bring them to final shape and complete cure. Postforming is limited to objects of uniform section, having only simple curves, for the most part. Formability is dependent upon the laminating material, however, and in general the limitations for the types of filler are as follows:

- Cotton-base grades—can be postformed to compound curves.
- Paper-base grades—can be given simple curves in postforming; sometimes referred to as postcurving.
- Glass fibre-base grades—cannot be post-



formed nor postcurved, but simple forms can be obtained by original molding in some cases.

Standardization of the thermosetting lam-[?]ates has been accomplished by the Na-[?]onal Electrical Manufacturers Association, [?]hich classifies the materials on the basis [?] the sheet filler employed, and the elec-[?]ical, mechanical, and heat-resisting charac-[?]ristics of the finished laminate. Three [?]pes are recognized: Type I, of cellulose [?]aper-base laminated material, including [?]x grades; Type II, of cellulose fabric-base [?]minated material, with four grades listed, [?]d Type III, of asbestos-base laminated [?]aterial, including two grades.

This classification has been adopted as [?]e basis for specifications by the A.S.T.M. in Specification D709-44T. It should be noticed that neither classification includes the glass fiber laminates; these are too new to be standardized and properly typed.

The N.E.M.A. types and their recommendations as to grades:

Type I—Cellulose paper-base laminates

Grade X—Primarily intended for mechanical applications, with electrical requirements of secondary importance. Not equal to fabric-base grades in impact strength. Should be used with discretion when high humidity may be encountered. Kraft paper laminating stock.

Grade P—Intended primarily for punching stock. More flexible and not quite as strong as Grade X. Moisture resistance and electrical properties intermediate between Grades X and XX. Plasticized varnish and rag or wood alpha paper.

Grade XX—Suitable for usual electrical applications. Good machinability. An electrical and mechanical general purpose laminate.

Grade XXP—Similar to Grade XX in electrical and moisture-resisting properties, but more suitable for hot punching. Intermediate between Grades P and XX in punching and cold flow characteristics.

Grade XXX—Better electrically than Grade XX, and suitable for high humidity applications. Has minimum cold flow characteristics. Higher resin content than Grade XX, and better moisture resistance, but slightly inferior mechanical properties.

Grade XXXP—Greatest electrical stability and lowest dielectric losses. Has greater coldflow than Grade XXX, is more suitable for hot punching, but less suitable than XXP grade.

Type 2—Cellulose fabric-base laminates

Grade C—The cotton fabric used as filler weighs more than 4 oz. per sq. yd., and has a thread count of not more than 72 per in. in the filler direction, and not more than 140 per in. total in both directions. A mechanical grade intended for use where shock loads may be encountered. Heavier weights of the coarse fabric base give higher impact resistance, but the machined edges become rougher and tend to become fuzzy. Suitable for low voltages only in electrical service.

Grade CE—A coarse fabric laminate similar to the C grade, but with higher resin content to increase moisture resistance. Impact resistance is lower. For electrical applications requiring greater toughness than Grade XX, or for mechnical applications demanding higher moisture resistance than Grade C.

Grade L—A fine weave cotton fabric, weighing less than 4 oz. per sq. yd., is the

Laminated Sheets, Thicknesses From 1/16-in. to 1-in., Inclusive

Type	Grade	Min. Tensile Str., Psi.	Min. Flexural Str., Psi.	Min. Compressive Str., Flatwise, Psi.	Min. Impact Str. (Izod), Ft.-Lb. Per In. Width		Power Factor, 1,000,000 Cyc., Max.	Dielectric Const. at 1,000,000 Cyc., Max.	Loss Factor at 1,000,000 Cyc., Max.
					Flatwise	Edgewise			
I	X	9000	16,000	none	1.3	0.50	none	none	none
	P	6000	11,000	none	—	0.50	none	none	none
	XX	8000	12,000	none	1.0	0.40	0.045	5.5	0.25
	XXP	6000	12,000	none	—	0.40	0.045	5.5	0.25
	XXX	6000	12,000	none	0.80	0.35	0.035	5.2	0.18
	XXXP	5000	12,000	none	—	0.30	0.030	5.2	0.16
II	C	7500	16,000	35,000	3.2	2.0	none	none	none
	CE	6500	13,000	34,000	2.3	1.3	0.065	6.0	0.40
	L	7000	15,000	30,000	2.5	1.2	none	none	none
	LE	6500	15,000	33,000	1.8	1.0	0.055	5.5	0.30
III	A	5000	10,000	30,000	1.8	0.8	none	none	none
	AA	6000	15,000	35,000	3.0	2.5	none	none	none

Minimum requirements for mechanical properties for sheets in thicknesses from 1-in. to 2-in., inclusive, are 10% lower than those given above.

Flatwise impact tests are not applicable to sheets under 1/2-in. thickness, and are not given for Grades P, XXP, and XXXP, as these grades are not available in thicknesses exceeding 1/4-in.

Dielectric Strength Requirements, Laminated Sheets, Min., V. Per Mil

	Thickness, in.	1/64 to 1/32	1/32 to 1/16	1/16 to 1/8	1/8 to 1/4	1/4 to 1/2	1/2 to 3/4	3/4 to 1	1 to 2
Type I, All Grades	Short time test	700	500	360	250	180	145	130	90
	Step-by-Step test	450	300	220	150	110	90	80	55
Type II, Grades CE and LE	Short time test	560	400	290	200	145	120	105	75
	Step-by-Step test	350	240	170	120	85	70	60	40

The dielectric strength is measured perpendicular to the laminations.

Maximum Permissible Water Absorption, Laminated Sheets

Thickness, In.	X	P	XX	XXP	XXX	XXXP	C	CE	L	LE	A	AA
1/32	8.0	7.0	3.1	3.1	1.8	1.8	—	—	6.0	3.6	1.9	—
1/16	6.0	5.0	2.0	2.0	1.2	1.2	4.4	1.8	2.5	1.8	1.5	1.9
3/32	4.2	3.6	1.6	1.6	1.0	1.0	3.2	1.5	1.9	1.5	1.1	1.5
1/8	3.3	2.8	1.3	1.3	0.85	0.85	2.5	1.4	1.6	1.25	0.95	0.95
3/16	2.3	2.1	1.0	1.0	0.70	0.70	1.9	1.2	1.3	1.0	0.85	0.80
1/4	1.8	1.7	0.85	0.85	0.60	0.60	1.6	1.0	1.1	0.90	0.70	0.70
1/2	1.1	—	0.55	—	0.45	—	1.2	0.70	0.80	0.65	0.55	0.55
3/4	0.85	—	0.50	—	0.40	—	1.1	0.65	0.75	0.60	0.50	0.50
1 and over	0.75	—	0.45	—	0.35	—	1.0	0.60	0.70	0.55	0.45	0.45

Permissible Variations in the Diameters of Tubes

Nominal Inside and Outside Diam.	Variations, Plus or Minus: Inside Diam.	Variations, Plus or Minus: Outside Diam.
⅛ to 23/32, inclusive	0.003	0.005
¾ to 1-15/16, inclusive	0.004	0.005
2 to 4, inclusive	0.008	0.008
4⅛ to 12⅛, inclusive (rolled only)	0.010	0.025

When the laminate is to be used in rod form, A.S.T.M. specifications for the various grades are especially concerned with mechanical properties.

Laminated Tubes

Type	Grade	Inside and Outside Dia.	Density, G. Per Cc.	Tensile Str., Min., Psi.	Compressive Str., Axial, Min., Psi.	Dielectric Str., Min., V. Per Mil, Short Time	Step-by-Step	Water Absorption, Max., Per Cent	Power Fact., 1,000,000 Cyc., Max.: As Rec'd	Power Fact.: 24-hr. Im.	Dielectric Constant 1,000,000 Cyc., Max.: As Rec'd	Dielectric Constant: 24-hr. Im.	Loss Fact., 1,000,000 Cyc., Max.: As Rec'd	Loss Fact.: 24-hr. Im.
I	X rolled	1 x 1⅛	1.10	7500	10,000	500	300	3.0	0.040	0.070	5.0	6.0	0.020	0.42
	XX rolled	1 x 1⅛	1.10	7000	12,000	400	250	2.5	0.040	0.055	5.0	6.0	0.020	0.33
	X molded	1 x 1⅛	1.25	9000	15,000	400	250	4.0	0.045	0.070	6.0	7.5	0.026	0.52
	XX molded	1 x 1⅛	1.25	7500	15,000	300	200	2.0	0.040	0.055	5.5	6.5	0.22	0.35
II	C rolled	1 x 1¼	1.10	5500	11,000	none	none	5.0						
	LE rolled	1 x 1⅛	1.10	5000	11,000	150	100	4.5						
	LE rolled	1 x 1¼	1.10	5000	11,000	150	100	2.5						
	CE molded	1 x 1¼	1.25	6500	19,000	175	100	1.5						
	L molded	1 x 1⅛	1.25	6500	18,000	none	none	3.5						
	L molded	1 x 1¼	1.25	6500	18,000	none	none	1.75						
	LE molded	1 x 1⅛	1.25	6000	19,000	150	90	2.20						
	LE molded	1 x 1¼	1.25	6000	19,000	175	110	1.10						

Dielectric strength is measured perpendicular to the laminations. Other electrical properties are specified for the "as received" laminate, and for the material after 24-hr. immersion in water at room temperature (25 C).
The dielectric strength indicated for X-grade rolled tube is obtainable only under dry conditions. The value is considerably lower when exposed to high humidity.

filler. The minimum thread count is 72 in the filler direction, and 140 total minimum in both directions. This is the grade used for mechanical applications in which fine machining is required. Especially useful in thicknesses of ½-in. or less. Not quite as tough as C grade. In the electrical field, suitable for low voltage applications only.

Grade LE—With fine weave filler similar to that in Grade L, but made with higher resin content to increase moisture resistance. For electrical applications requiring greater toughness than the XX grade, or for mechanical applications requiring higher moisture resistance; also offers beter machining properties and finer appearance than Grade CE.

Type III—Asbestos-base laminates

Grade A—Asbestos paper is the laminating material. Because of high inorganic content, this grade is more resistant to flame and slightly more resistant to heat than the other laminates. Offers maximum dimensional stability when exposed to moisture, but electrical properties are variable. Suitable for only low voltage applications.

Grade AA—Asbestos fabric laminate. Properties similar to those of Grade A, but stronger and tougher. Flame resistance and dimensional stability when exposed to

Molded Rods

Type	Grade	Diam., In.	Density, Min., G. Per Cc.	Tensile Str., Min., Psi.	Flexural Str., Min., Psi.	Compressive Str., Axial Min., Psi.
I	XX	1/8 to 1, incl.	1.30	8500	15,000	20,000
		Over 1 to 2, incl.	1.30	6500	12,000	20,000
	XXX	1/8 to 1, incl.	1.25	8000	13,000	20,000
		Over 1 to 2, incl.	1.25	6000	11,000	20,000
	C	1/4 to 1/2, incl.	1.28	7500	17,000	20,000
		Over 1/2 to 1, incl.	1.28	8000	17,000	20,000
		Over 1 to 2, incl.	1.28	6500	14,000	20,000
	CE	1/4 to 1/2, incl.	1.26	6500	12,000	21,000
		Over 1/2 to 1, incl.	1.26	7000	14,000	21,000
		Over 1 to 2, incl.	1.26	6000	12,000	21,000
II	L	3/16 to 1, incl.	1.28	8000	16,000	20,000
		Over 1 to 2, incl.	1.26	6500	13,000	20,000
	LE	3/16 to 1, incl.	1.26	6000	12,000	21,000
		Over 1 to 2, incl.	1.26	4800	9,000	21,000
	A	1/4 to 1/2, incl.	1.55	7000	10,000	15,000
		Over 1/2 to 1, incl.	1.55	6000	10,000	15,000
		Over 1 to 2, incl.	1.55	5000	9,000	15,000
	AA	1/2 to 1, incl.	1.45	6000	11,000	19,000
		Over 1 to 2, incl.	1.45	5500	9,000	19,000

Water Absorption, 24-hr. Immersion, Max., Per Cent

Grade	XX	XXX	C	CE	L	LE	A	AA
Diam., In.								
1/8	—	1.5	—	—	—	—	—	—
1/4	1.5	1.0	2.5	1.5	1.5	1.2	2.0	—
1/2	1.0	0.75	2.0	1.0	1.2	0.90	1.5	1.25
1	1.0	0.75	2.0	1.0	1.2	0.90	1.5	1.25
Over 1, and 2	1.3	0.75	1.5	1.2	1.2	1.1	1.75	1.75

Properties of Glass Fiber Laminates (Average)

	Tensile Str., Psi.	Flexural Str., Psi.	Compressive Str., Psi. (Flatwise)	Impact (Izod) Ft.-Lb. In.Notch Flatwise	Impact (Izod) Ft.-Lb. In.Notch Crosswise	Dielectric Str. V./Mil Short Time	Dielectric Str. V./Mil Step-by-Step	Water Absorption, %
MF-66	10,000	14,000	42,000	1.0	1.0	550	350	0.30
FF-10	11,000	19,000	49,000	8.5	4.4	365	250	1.9
FF-41	17,400	27,400	60,300	12.2	7.7	290	190	2.5
FF-55	25,000	35,000	55,000	12.0	12.0	500	300	1.7
GLF	16,000	22,000	40,000			300	225	1.2
GLF-M	14,000	20,000	40,000			350	250	0.9

moisture are the controlling characteristics. For only low voltage applications in the electrical field.

The A.S.T.M. specification for laminated resins covers the material in three forms, namely, sheets, rolled or molded tubes, and molded rods. Finishes listed are: Dull, semigloss, ground, buffed, polished, and varnished. In sheet form, Grades XX, XXX, CE, LE, are available in semigloss or polished; X, C, L, A, AA, semigloss only; and P, XXP, and XXXP are available in semigloss or dull. All grades are available as tubing or rods in ground, buffed, or varnished finish, and as molded rectangular forms in semigloss, ground, or varnished finish. Colors are ordinarily limited to natural, black, or chocolate, although color possibilities are wider, extending to most darker shades.

The A.S.T.M. specifications have been widely adopted, and most suppliers of thermosetting laminates of types covered by the specifications list their materials by A.S.T.M. grade designations. Because of the difficulty of fixing definite physical properties for a material composite in nature, tables of physical standards tend to become cumbersome. Water absorption in particular is dependent upon the amount of exposed surface of the material, and must be given in terms of form and size to have any meaning. Mechanical and electrical properties of the A.S.T.M. grades are given.

In addition to the standard N.E.M.A. grades, many manufacturers produce special materials having properties intended to meet conditions in a given application. Also, new fillers have been developed during the war, but have not yet been established as standard industrial materials. Glass fiber laminates have shown high strength properties and excellent heat resistance, but are still too new to have these properties established and standardized.

Among the glass fiber laminates now being produced are Grade MF-66, a glass mat material for electrical applications requiring low loss at high frequencies; FF-10, combining good dielectric strength and heat resistance; FF-41, with high resistance to arcing at low amperage; FF-55, a fine weave glass fiber laminate for arcing resistance and heat resistance. These are Formica Insulator Co. products. Synthane Corp. has GLF, a phenolic laminate with high mechanical properties, and GLF-M, a melamine type having flame, arc, and heat resistance with good strength. Westinghouse 259 grade melamine is another fire resistant glass base laminate.

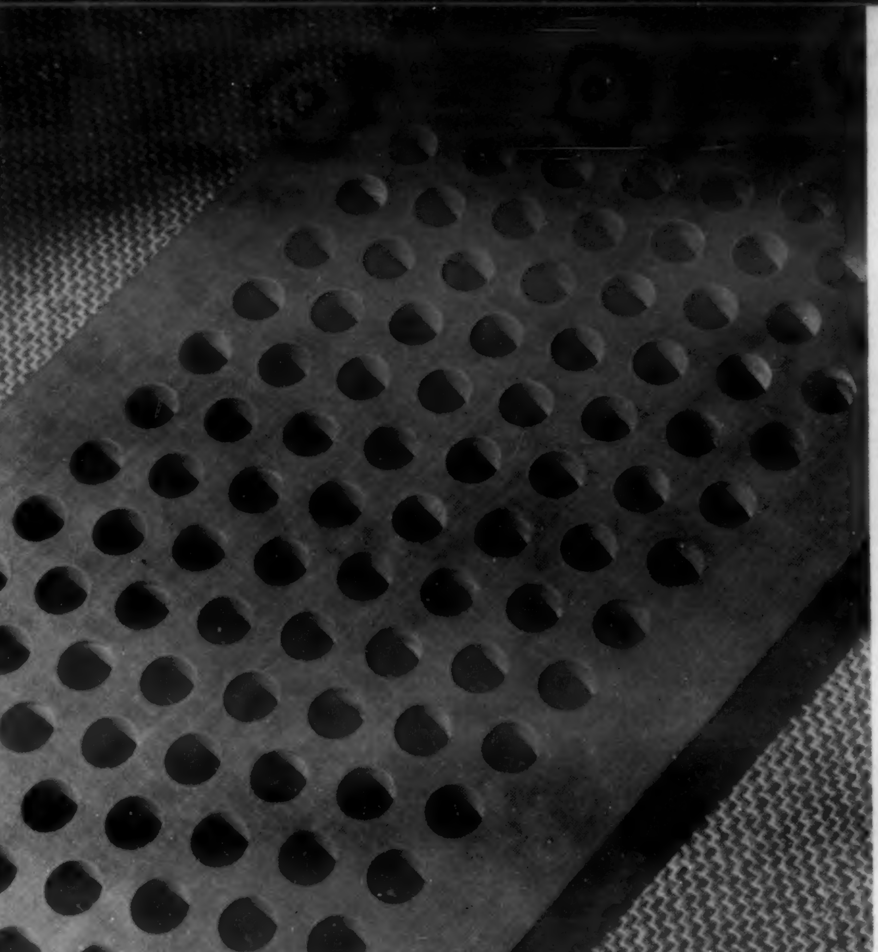
High-strength glass-fiber laminates were developed during the war for aviators' body-armor, and these were made with polyester resins. Tensile strengths of 60,000 p.s.i. and higher were reported.

The melamine resins are especially suitable for fire-resistant laminates, as upon heating they liberate nitrogen gas, which does not support combustion.

Special laminates using fillers of the standard types already described include engraving stock, made by General Electric Corp. and Panelyte Div. of St. Regis Paper Co., and possessing a surface contrasting in color with the core; a black surface is used over a white core, or vice versa. It is used for nameplates, panels, etc. Laminates containing both paper and cloth in the filler are used for punching stock, as in radios, where toughness is needed. Paper laminates with urea resin are sufficiently translucent for use in lighting panels and signs.

Several grades of Micarta (Westinghouse) are especially fabricated for use in heavy duty bearings, as in the steel industry. These are coarse weave fabric laminates, or laminates of extra heavy weave fabric, and are intended to run with water lubrication, although oil or grease can be used. They combine high abrasion resistance, high compressive strength, and low coefficient of friction. Another grade of laminate intended for bearings is self-lubricated with graphite.

A paper-base laminate produced largely for refrigerator construction has as its special property the avoidance of the odor characteristic of the phenol-type resins. When extreme flexibility is required, a



This suction box cover, machined from flat Micarta plate, shows how cleanly laminated plastics can be machined. (Courtesy: Westinghouse Electric Corp.)

grade especially produced to permit bending around short radii is available. A cold punching grade is obtainable that can be used in 1/16-in. thicknesses for intricate shapes, and for simple shapes can be cold punched in thicknesses up to 1/8 in. High moisture-resistance grades, used for small pump vanes, water pump gears, and similar applications, have been found satisfactory for continuous use in water at temperatures to 212 F. Formica Insulator Co. produces these grades in fabric-base laminates, strength being slightly lowered to obtain maximum water resistance. Panelyte Division of St. Regis Paper Co. has a fabric-base type with high water resistance and dimensional stability, intended especially for marine bearings. Westinghouse Electric Corp. produces grades of Micarta for use in marine bearings also.

Heat resisting laminates, usually with glass fiber or asbestos filler, are suitable for continuous use at temperatures up to 300 F, and will withstand intermittent exposure to heat about 20 F higher. A woven asbestos fabric filled material produced by National Vulcanized Fiber Co. is credited with short time heat resistance up to about 400 F. Formica Insulator Co. offers a laminate with asbestos webbing filler for which high arcing and heat resistance, combined with tensile strength of 27,000 psi., are claimed.

An impregnated compressed wood, made with parallel laminations, attains a tensile strength of about 30,000 psi. Its compressive strength is only 20,000 psi., however.

While the laminated plastics have been from their beginning important electrical construction materials, the growing use of high frequency currents has made new demands upon them. High frequency work in such fields as radio and industrial heating has dictated new electrical requirements for loss factors, etc., at frequencies of 1,000,000 cycles. These have been met by grades having especially high moisture resistance, usually at the sacrifice of some strength.

Low Pressure Laminates

If there be a part of the structural plastics industry that could be called a glamour section, it would be in the field of the low pressure laminates. Most of spectacular developments in laminates that have caught the public's attention have been here. Such items as 22-ft boat hulls, molded in one piece; droppable fuel tanks for aircraft, made from impregnated fiber, and caskets, baby carriages, and panelling for prefabricated houses are products of low pressure forming.

Low pressure laminating is a war baby. It had its origin in the need for large pieces of plastic laminate, of good strength, molded to forms frequently too complicated for the established high pressure techniques to produce. Using methods—and frequently equipment—borrowed from the plywood and the rubber industries, varieties of the resins well known in high pressure laminates were formed to the desired shapes.

The end of the war left the new industry in a somewhat difficult position. Industry generally began as soon as possible to reconvert to its peacetime products, and to reestablish contacts with its suppliers and its outlets. For the low pressure laminators there was no reconversion. They were compelled to start from scratch again, to decide what to make, to do all the engineering associated with a new product, and to seek outlets for articles that had not yet received public recognition.

These difficulties had their compensations, however, for the industry had no obsolete machinery to be replaced, no traditions to combat, and the public was already favorably prejudiced toward plastics, partly because of the wartime industrial successes. The industry has found the purchasing public quite ready to accept molded plastic boat hulls, molded baby carriages, and similar products. Industry has accepted the low pressure laminates for aircraft parts, panels for architectural use, and the like.

Although it has already achieved the status of a substantial industry, low pressure laminating is still using techniques adapted from other industries, principally the rubber industry, the plywood industry, and the felt hat industry. Equipment also is of the type used in those industries, modified sufficiently to permit its use with the new materials. As the industry continues, and as research and development work is done, newer and probably more economical methods and machinery can be expected.

Until now, costs have been the biggest problem. Several authorities have said that the methods now in use will not stand up under severe price competition from other industries. This price competition has not yet been experienced, and the low pressure laminators have been able to produce their finished articles, quickly molded and with low finishing costs, at prices competitive with those of similar articles made of other materials.

Material cost comparisons are difficult to make, because the laminates are not sold as materials in laminated form. The low-cost phenolic resins for low pressure laminating will cost about 17 to 30 cents per lb., while the polyester types will be approximately 50 cents. Cotton fabric, sold by the yard, may cost about 60 cents per lb. Paper for laminating may be 20 cents per lb. Against these figures there are sheet steel at about 8 cents per lb., sheet aluminum at approximately 25 cents, and plywood at about 20 cents per lb. when the price is reduced to a per pound basis.

As has been pointed out earlier, the laminators have been meeting competition by using their higher priced material in molding operations that greatly reduce the amount of labor required. Furthermore, low pressure laminating can use comparatively inexpensive molds, so reducing tooling costs.

Asked about comparative costs for a

molded boat hull as against one of plywood, a laminator estimated that his material, formed, but without including any bookkeeping items such as overhead, amortization of molds, equipment, or plant, or any labor charges, would cost about 50 cents per sq. ft. This against plywood at 20 cents per sq. ft. indicates the difference to be made up in labor costs. The fact that selling prices for plywood boats and for plastic molded boats are comparable seems to mean that cost differences can be closed.

Molds in cast iron have been made with walls as thin as ¼-in., with steam pipes inside to provide the heat for curing. Aluminum molds have won favor for large pieces because of their lightness. An aluminum mold 17-ft. long is in use at Lincoln Industries, Inc., and larger ones are under construction. With molds of aluminum or Kirksite the steam pipes can be cast in the mold. Walls are about ¾ to 1 in. thick.

The mold for the baby carriage is of Meehanite, with coils cast in place. This well-designed plastic item is another example of the savings to be obtained with low pressure laminates. It is molded in one piece, and floor-to-floor time is about 5 min.

While the low pressure laminates have been defined as those made at pressures below 500 psi., the pressures commonly used are below 250 psi. As a vacuum is a very convenient way of applying atmospheric pressure, certain types of laminating are done customarily at 15 psi. Finally, there are those laminates produced under pressures no greater than are necessary to bring the materials into contact—the contact laminates.

Methods of applying the pressures are of four types. These are given in outline form as follows:

(1) Contact Pressure—need be just sufficient to bring the laminating materials into contact, and to exclude air pockets. Glass can be used for the plates between which the laminate is formed. The tension in cylindrical windings can be used to establish a bond, or windings can be made about a male mold to form the laminates.

(2) Fluid Pressure—one member of the mold is solid and the other is a flexible membrane against which a fluid presses. Steam, air, and inert gas have been so used when compressible fluids have been required. Water and oil have been used as noncompressible fluids. Greater ease of fabrication is commonly obtained by combining some of the fluids, the combination providing higher pressures with greater safety.

(a) Vacuum—air is withdrawn from the space between the solid mold and the flexible membrane, and atmospheric pressure forces the membrane and the laminate against the mold.

(b) Pressure Hose—fluid pressure in a flexible hose can be applied to a given spot by confining the pressure above the desired area.

(c) Diaphragm—the solid mold, membrane, and pressure chamber are built as a unit. As fluid pressure is confined only over the membrane, a clamping force greater than the molding pressure is needed to hold the mold against the membrane and to retain it there. The pressure chamber can be boxlike, or it may conform to the shape of the membrane to reduce the volume of fluid needed.

(d) Autoclave—mold and membrane are placed inside a pressure chamber, and pressure is applied to both.

(1) Bag Molding—the mold is completely enclosed in the membrane and the membrane is vented to the outside of the autoclave.

(2) Blanket Molding—the membrane is clamped to the solid mold.

(3) Flexible Pressure—one member of the mold is solid, the other is a pliable mass capable of being forced downward into the contours of the solid mold.

(a) Pliable part of the mold flat, and returns to its original shape after pressure is released.

(b) Pliable part of the mold shaped to approximate contour of the solid part, and forced against the solid mold wall.

(4) Compression—pressure can be applied by various devices.

(a) Compression Press—mechanical or hydraulic; similar to those used in high pressure work except that the equipment can be lighter.

(b) Straps

(c) Clamps

(d) Nailing Strips

(e) Screw Press

When fluid pressure is used, the fluid may be the heating agent also. Steam, water, air, oil, or inert gas are so used. In other cases room temperature suffices, while ovens, infra-red lamps, electrical resistance heating units, and high frequency or dielectric heating are used for higher temperatures.

The resins used in low pressure laminating include both thermosetting and thermoplastic types. The former group is the more interesting from the viewpoint of the structural designer, but both will be briefly considered for the sake of completeness. The low pressure resins can be conveniently grouped into the cold set resins, setting at room temperature, and the hot set resins, setting at elevated temperatures.

Of the cold set resins, the thermoplastic types set by evaporation of a solvent. These include vinyls and cellulose esters. The thermosetting resins the phenolics, the urea and resorcin compounds, cure at low temperatures because of the presence of high reacting catalysts.

Thermosetting resins in the hot-set group include the usual phenolics, ureas, melamines, and resorcins, along with the allyls and styrenes. Heat is needed for polymerization. Heat is necessary for the thermoplastic types also, in order to soften them to the point at which they will flow during molding. They include styrene floss, polyvinyl resins, ethyl cellulose, and cellulose acetate.

Methods for applying the resin are more varied than those used in high pressure laminating. The resin can be in solution and applied as a varnish, or in latex form, or in some cases may be molten or applied as a dry powder. They can be classified as follows:

(1) Immersion—similar to the method used with high pressure laminates. The filler passes through the resin varnish, and excess is removed by rolls, doctor blades, or suction screen.

(a) At atmospheric pressure—most fillers do not need exrta pressure to force the resin solution into the filler.

(b) Vacuum and/or pressure — used when the filler is so compact that the resin varnish will not penetrate without additional force.

(2) Dusting—dry powdered resin is dusted over the surface of the filler mass, vibrated to penetrate, then sintered to fix it in position.

(3) Brushing—brushing and scrubbing force the varnish into the filler.

(4) Rolling—the varnish is flooded onto the laminating web and squeezed into it by rolls.

(5) Spraying—careful control of the resin content is facilitated when it is applied by spraying.

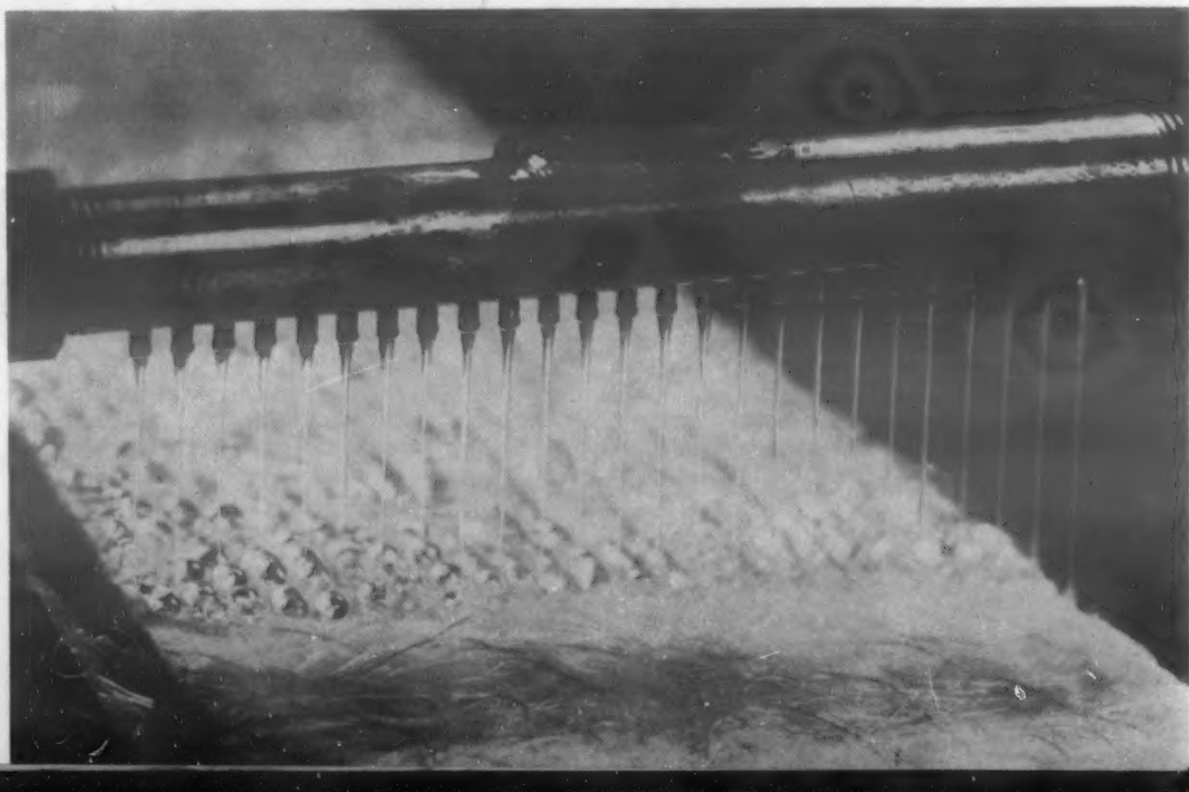
(6) Injection—with the filler confined in closed molds, the pure molten resin is injected under pressure.

(7) Films—special resin films placed between filler sheets will bond and partly penetrate them.

As with the high pressure laminates, the type of filler used is of great importance in obtaining adequate strength properties. The fibers include both those of natural and of synthetic origin; they are used in many different forms, such as woven, felted, or oriented.

The natural-fiber fillers, classified accord-

Applying resin to glass fiber mat preparatory to laminating. (Courtesy: Owens-Corning Fiberglas Corp.)



ing to form, are: (1) Veneers or thin plies of natural wood; (2) Pulps, used either straight or in various combinations; wood pulps include alphas, sulphite, kraft, and soda pulps, while rag pulp is also used; (3) Paper, produced from groundwood, kraft, Mitscherlich sulphite, alpha, and rag pulps, in various combinations; (4) Felted fibers, of cotton, sisal, manila, jute, or asbestos; (5) Woven fibers, of cotton, linen, or jute.

Synthetic fillers form a much shorter list. They are glass filaments, used either in felted form or woven into fabric; styrene floss, used as a felted material; rayons of various kinds, woven into fabric, and nylon used as a fabric.

Because pressures are low, the molds can be made of materials of low tensile strength. The material to be used for making the molds depends to a great extent upon the production run; if short, only low-cost, easily prepared materials can be considered if die costs are to be amortized and final costs held to reasonable figures. The mold materials are here given: (1) wood; (2) plaster of paris; (3) Form-rite; (4) cement; (5) spray metal; (6) Kirksite; (7) cast aluminum; (8) cast bronze; (9) cast iron; (10) sheet steel; (11) tool steel. Cost relationships may vary rather widely with individual jobs.

Low pressure laminating should be given consideration as a fabricating method whenever the plastic part to be produced lends itself to molding. While high pressure laminates can be formed to some extent in postforming operations, their possibilities are limited to relatively simple shapes. When the part to be formed is of considerable size, high pressure laminating would be ruled out. If the part is of small size, simple in form, but of such shape that molding is preferred to machining from sheet, tube, or rod, either high pressure laminating or molding of the macerated sheet would be indicated as a likely method. If superior moisture resistance or excellent electrical properties were required, the choice would again be inclined toward the high pressure techniques. However, when parts are to be molded to a complex shape, or are large in size, or when costly tooling is undesirable, low pressure laminating may provide the solution.

Reduced molding pressures in flat sheets may: (1) result in less warpage in the finished sheet, as the filler is subjected to less strain, and has less tendency to stress relief when the pressure is released; (2) improved toughness, especially when glass fiber cloth is used as the filler; (3) help in holding thickness to closer tolerances, due to less platen deflection.

The contact laminates, already referred to, make use of several newer types of resin, usually liquid, but used without a solvent or diluent. These anhydrous resins therefore give off no moisture upon cure. They are usually polyesters, or styrene derivatives, or can be mixtures of several chemical types. Their use has made possible an interesting development in the production of standard forms, the continuous laminated sheet. This sheet is made by impregnating a filler web with a contact resin by one of the usual methods, then passing the web through a tunnel-type oven in which time and temperature are so regulated that polymerization is complete when travel through the oven is concluded. The resulting laminate is cut into sheets, or can be wound into rolls if flexible.

Low pressure laminates are being used for such items as aircraft rudder and wing control surfaces, cartop boats, 8-ft.-long caskets, baby bassinets, wall panels, instrument cases, radar housings, electronic insulation, luggage, artificial limbs, refrigerator panels, table tops, and ice buckets.

Composite and Sandwich Materials

Probably no field in materials production offer such wide possibilities as does the fabrication of composites. Lightweight plywood is surfaced with metal to produce a low cost, low weight, high strength sheet. Rubber is bonded directly to metal to produce a new type of shock absorber. Plastic sheeting is bonded to Masonite board in an attractive construction panel. Carbonized linings in sheet metal firedoors lower weight and increase heat resistance. Vulcanized fiber as a facing for plywood makes a lightweight air carbo crating. Aluminum sheets with a core of balsa develop extreme rigidity with almost feather lightness. The materials engineer has a practically unlimited choice of the properties to be combined in a composite material.

Only the plastics are mentioned here. In a sense all the composites are plastics materials, as they use a resinous glue or obtain a bond by curing a plastic sheet directly onto another material. Those that have only the use of a resinous glue to tie them to the plastics industry, however, can be more properly considered in connection with some other group.

The so called "sandwich" laminates have attracted the most attention, and are probably the most important from the viewpoint of the designer and the structural engineer. These have one feature in common—they utilize a low-density core and higher-strength facing materials. The core permits lightness of weight, while at the same time serving to hold the facing layers in position, as the web of a beam holds the flanges.

The early plywoods, in which a durable wood was used for facing and a softer, less dense wood for filler, were sandwich materials. The idea was carried to a higher degree in the DeHavilland Mosquito Bomber during the war, when hardwood facings enclosed a balsa wood core. Thin aluminum sheets with a balsa core formed a corresponding material used in parts of all-aluminum aircraft.

Plastics make excellent core and facing materials, and some of the most interesting of the present sandwich materials are those composed in part or wholly of plastics. Facing materials can be thin laminates, and several sandwiches now going into aircraft have glass fiber laminates as facing. When combined with a foamed or cellular plastic core they make high-strength, very light weight sheets.

The core material must meet the following requirements:

(1) It must be sufficiently strong in tension to prevent buckling of the faces through tensile failure in the core itself when a force is applied perpendicular to the surface of the sandwich.

(2) It must be sufficiently strong in compression to resist localized pressures due to rough handling.

(3) It must be sufficiently tough to resist splitting and failure in the core before the faces can demonstrate full strength.

(4) It must be sufficiently rigid to hold the sandwich material stable while the faces carry the load. A soft or flexible core would cause premature failure.

(5) It must have sufficient shear strength to resist core failure in shear due to buckling.

(6) It must possess adequate resistance to impact and vibration. Materials granular in structure show poor vibration resistance.

For specific uses, one or more of the following properties may be important: (1) heat resistance; (2) thermal conductivity; (3) acoustical properties; (4) flammability characteristics; (5) water resistance; (6) chemical resistance.

General types or core materials are:

(1) Foamed thermosetting resins, such as Pliofoam, an urea-formaldehyde resin; Testolite, a phenol-formaldehyde plastic; Laminac, also a phenol-formalydehyde, and Thermazote, likewise a phenol-formaldehyde material.

(2) Foamed thermoplastic resins, such as Styrofoam, a polystyrene; CCA (cellular cellulose acetate), and Plastazote, vinyl formal.

(3) Foamed rubbers, such as Fotofoam, Cell-Tite, and Rubatex.

(4) Honeycomb cores, of glass, fabric, or paper in grids, with a resin binder.

(5) Natural cores, such as balsa.

(6) Foamed glass, such as P. C. Foamglass.

(7) Foamed calcium alginate.

(8) Impregnated fibrous cores.

In the case of the foamed core materials, the structure is obtained by solvent blowing agents, by solids yielding a large volume of gas, by a condensation reaction, or by monomer vapor. The gas may be released in a reaction, or it can be obtained by releasing pressure in compression or extrusion equipment. Some of the thermosetting types can be poured, then foamed in place.

Most of these foamed resins are excellent heat insulators, and when prices have been brought down to competitive levels should find wide application in that field. They

are already being so used to some extent.

The foamed thermosetting plastics are generally more moisture resistant than the thermoplastics. The thermoplastic types can be formed to some extent upon heating. For all of the foamed materials, variable densities are available, the density increasing as strength characteristics increase. Most of them are in limited or experimental production, and tables of densities of available types with corresponding strengths cannot yet be accurately compiled.

Cellular cellulose acetate, for instance, is available in four weights upon order, 4-to-5, 6-to-7, 7-to-8, and 8-to-9 lb. per cu. ft. As a great many combinations of core materials, core densities, core sizes, facing materials, facing strengths, and facing sizes are available, strength properties could be given for specific combinations only. A few standard combinations are being prepared, but the plastic sandwich materials are still in the "special order" category for the most part.

The laminates are made by bonding the facing materials to the core with resinous glues. Phenol-formaldehyde, resorcinol-formaldehyde, and urea-formaldehyde types are widely used for attaching wood or plastic facings, and combination adhesives are usually used for bonding the cores to metal. The metal facings of aluminum, magnesium, steel, or stainless steel, are primed with a coating of Cycle-Weld, Reanite, Bostik, Cordo Bond, etc., the prime coat is dried and cured, and the lamination is completed with a conventional formaldehyde-type adhesive. Use of high-frequency heating shortens the time of cure.

Honeycomb cores are of particular interest as components in sandwich materials. Several types of honeycomb are in production at present; about 90% of it utilizes an 80-sq. weave cotton fabric, impregnated with phenolic resin. Other honeycomb materials are made with paper or glass cloth laminates. Phenolic resin is used for the paper-base types, while a polyester resin is used with the glass fiber.

The standard honeycomb made from cotton-base laminate weigh 3¾ lb. per cu.ft., and paper laminates weigh from 2 to 3½ lb. per cu. ft. Commercial panels range from ¼ in. to 2 in. in thickness. Costs are still high—a 7/16-in. panel faced with 1/16-in. mahogany cost $1.50 per sq. ft. recently—but they are declining steadily, and may soon be available for strongly competitive fields such as housing. At present they are largely used in the aircraft industry, where reduced weights in such parts as flooring, columns, doors, and hatches, pay large dividends.

In a recent comparison of aircraft flooring materials, a panel of cotton honeycomb was tested against the usual ⅜-in. spruce plywood panel. The honeycomb panel saved 30% of the weight of the plywood panel, and was 100% stronger. It was estimated that a weight saving of 800 lb. would result from using the plastic flooring in a commercial transport plane, and as weight savings are calculated to be worth annually about the price of gold, the savings would amount to several hundred thousand dollars per year.

These Fiberglas reinforced plastic parts illustrate adaptability of the materials to fabrication of complex and compound-curve parts.

Curved panels are possible with honeycomb cores, as with most of the foamed plastics. Compound curves have been produced also. Low pressure paper-base laminates, plywood, aluminum, and other facings have been used in aircraft sandwich laminates. Because much of the bracing and stiffening necessary with thin sheet material can be eliminated when sandwich types are used, design and fabrication can be simplified.

Sandwich construction is now being used for aircraft fuselage sections, doors, bulkhead panels, ribs and other reinforcing members, wing and tail structures, collapsible tables, furniture and cabinets. Applications in other forms of transportation, such as boats, trailers, refrigerated trucks, and railway cars, are being studied. Other uses under consideration are in luggage construction, large commercial refrigeration units, prefabricated housing, furniture, toys, and sports items.

In addition to the true sandwich materials, characterized by a lightweight core, there are composite materials in which a facing of a plastic over a nonplastic, or of one plastic over another, provide desirable features. Plywood and Masonite board faced with plastic are standard materials of construction in the manufacture of motor coaches, railway cars, and aircraft, the plastic face providing a durable surface that does not need paint. Laminates of this sort are made without use of a glue binder. The plastic face, usually a formaldehyde-type thermosetting resin, is applied and cured in place, and is bonded by the cure.

During the war instrument cases were made by applying vinyl faces over a phenolic fabric laminated core, the rubbery vinyl providing a desirable surface while the phenolic laminate gave the case rigidity.

Like the low pressure laminates, the sandwich materials are war babies. They have not yet standardized their materials and reduced costs to the point that they can compete strongly with established structurals except in the aircraft industry, where weight saving offers a very high premium. They are beginning to challenge accepted materials in many fields, however, and will certainly enter some of them, particularly in other branches of transportation.

Machining Structural Plastics

Several methods of fabrication useful in working metals are not adaptable to plastics laminates. All hot forming operations must be ruled out, and likewise all cold press-forming procedures. After the laminate has been formed, machining is practically the only way to reshape the piece. Even the thermosetting resins have a certain formability at elevated temperatures, but this is so limited that it is not widely used as a forming method.

Laminated plastics machine without any difficulty. Even the glass fiber laminates can be cut satisfactorily, although carbide-tipped tools are recommended for speed and finish.

For the most part ordinary high speed steel tools will suffice. Several grades of the phenolics intended as bearing stock should be cut with carbide-tipped tools, and use of these tools for all cutting of laminates will permit higher cutting speeds.

Turning—Roughing cuts can be made with carbon steel tools. Tools should be kept sharp, and the work rotated at a speed about 25% higher than that for ferrous metals. Clearance should be ample; at least 30 deg. is recommended. The tool should be ground with a flat lip, and with about 12 deg. side clearance. Peripheral speeds of 400 ft. per min. can be used with high speed tools, while with carbide-tipped tools speeds as high as 700 ft. per min. may be satisfactory.

Cutting should be done dry.

In facing or boring operations the tool should be fed toward the center of the work, so that there will be no tendency to separate the plies at the end of the cut.

Stock allowance for finishing should be not less than 0.010 in. after the roughing cut. The feed for the roughing cut may be as coarse as possible but the finishing cut should be made with a feed of about 0.010 in.

Drilling—Best results will be obtained with the drills designed especially for plastics. These have a steeper twist, with a narrow web and highly polished flutes to facilitate chip removal. Their use in drilling holes larger than 3/16-in. in size is especially desirable.

The highest speeds possible may be used in drilling laminates. A ¼-in. drill may turn at 3000 rpm.; faster speeds, to about 10,000 rpm., can be used for smaller sizes, and proportionately slower speeds for larger diameters.

The drill should not be forced, especially when drilling parallel to the laminations. Frequent withdrawing and removal of chips will prevent packing, and will permit cooling of the drill also. The laminate should be clamped between plates or otherwise supported when drilling parallel to the layers to prevent splitting.

When drilling small holes in plastics with ordinary high speed drills, the cutting edge should be ground with no rake. Rake should be removed by grinding the lips parallel to the drill axis, as for brass. Grinding the cutting edges to a 94 deg. angle is recommended for thick sections, while a 55 deg. point can be used for thin sections.

Because of the plastic quality of the material, holes drilled in laminates are usually from 0.001 to 0.003 in. under the drill size. If the drill is being used dull, the hole may be several additional thousandths undersize. When greater precision is required a drill about 0.002 in. oversize can be used. Some authorities suggest grinding the drill slightly off center, but precision is difficult to obtain by such methods.

Drilling should be done dry, especially with the smaller sizes. A little coolant can be used when drilling large holes, but it must be used sparingly, and any oil or fatty compound should be avoided. Water has been used successfully as a coolant. Removal of chips by suction, and playing a jet of compressed air on the drill, are methods that have shown as good results as any.

Tapping—The taps used for metal are suitable for tapping plastics laminates also. The tap drill size should be changed, however, to one 0.003 to 0.006 in. larger to counteract the tendency of the drill to cut undersize. A Class 2 fit, with 65 to 70% of thread, is the best that should be expected of tapped holes in plastics; additional thread depth increases the risk of breakage.

For production work the taps can be nitrided or chrome plated to increase life. Grinding a 5-deg. negative rake on the front face of the land helps to prevent binding when backing out. Threads will be more accurately sized if the tap is 0.002 to 0.006 in. oversize. Undersize taps can be built up by chrome plating.

For machine tapping a speed of 40 to 80 surface ft. per min. is good practice. Water can be used as a lubricant if required. When holes over 1½-in. in dia. are to be tapped, collapsible taps will be found useful.

Punching—Blanking of sheet laminates is included under the head of punching. For punching either holes or blanks it is important that there be minimum clearance between the punch and the die, and between the punch and the pressure stripper, if clean-edged holes or blanks are to be produced. As in drilling, an allowance must be made for the plasticity of the material during punching if holes are to be sized accurately.

Compound dies are the most satisfactory for intricate pieces. If high speed fabrication is desired, progressive dies are best. With a punch press speeds to 150 strokes per min. are common.

Punching is facilitated by heating the laminate to about 250 F. This is especially advantageous with the thicker sheets. An additional allowance must be made for shrinkage when punching hot stock, and this allowance will depend upon the thickness of the stock, the temperature, and the size of the hole. For a ⅛-in. hole in 1/16-in. stock, the allowance might be 0.003 to 0.005 in. over the nominal punch size, while for the same size hole in ⅛-in. stock it might be 0.012 to 0.015 in.

Tolerances can be held more closely on drilled holes than on punched holes. The diameter of a punched hole should not be less than the thickness of the sheet, while the distance between the edges of punched holes, or between the edge of a punched hole and the edge of the piece, should be not less than 1½ times the thickness of the sheet.

Blanking laminated sheets in a press sometimes leaves the edges rough. To obtain smooth edges, a shaving operation may follow the blanking, provided the blanking die is made to cut oversize by about 1/16 to ⅛ in. The blank is then trimmed by forcing it through a hollow die of hardened tool steel or of soft steel with hard surfaced cutting edges. A brass of soft steel plate on the ram of the press forces the blank through the die. Thick sheets can be shaved hot.

Milling—High speed milling cutters can be used for machining plastics, but for high production carbide-tipped cutters are preferable. The cutting angle should have a slight rake, usually about 3- to 5-deg. more than for cutting metal. Speeds are about the same as for brass or soft steel. Climb milling is to be preferred, as it does not tend to separate the laminations in the sheet.

The feed should be about the same as for brass, and the cutter should be made to cut full, if the nature of the work permits. Sharp cutters produce a better surface, and heat the work less.

Sawing—Laminates can be sawn with circular saws, band saws, abrasive saws, or metal-cutting hand saws. For hand saws, blades with about 10 teeth to the in. are satisfactory. Band saws are the most adaptable, and either the metal-cutting variety or the woodworking type with metal-cutting saw is satisfactory.

Sawing with an abrasive saw is best done by taking several cuts, passing the saw back and forth through the work. Cutting the full depth in one pass causes heating of the work, and shortens the life of the saw.

Shearing—Sheet stock can be sheared on metal squaring shears. Thin sheets and punching stock may be sheared cold, but heavier weights are cut most satisfactorily when heated to 200 to 250 F.

Producers of Plastic Laminates

Trade Name	Company
Bondelite	McInerney Plastics Co.
Bondex	McInerney Plastics Co.
Cellanite	Continental Diamond Fibre Co.
Duraloy	Detroit Paper Products Corp.
Farlite	Farley & Loetscher Mfg. Co.
Formica	Formica Insulation Co.
Insurok	The Richardson Co.
Lamatex	Wills & Roberts Plastic Mfg. Co.
Lamicoid	Mica Insulator Co.
Lignolite	Marathon Corp.
Marcolite	Marco Chemicals Inc.
Micabond	Continental-Diamond Fibre Co.
Micarta	Westinghouse Electric Corp.
Mir-Con	Detroit Paper Products Corp.
Ohmoid	Wilmington Fibre Co.
Panelyte	St. Regis Paper Co.
Phenolite	Phenolite Co.
Phenopreg	Detroit Wax Paper Co.
Phenrok	Detroit Wax Paper Co.
Spaulding	Spaulding Fibre Co., Inc.
Spauldite	Spaulding Fibre Co., Inc.
Structomold	McDonnell Aircraft Corp.
Synthane	Synthane Corp.
Synton	King Plastics Corp.
Taylor	Taylor Fibre Co.
Textolite	General Electric Co.
Vulcoid	Continental-Diamond Fibre Co.

CONTENTS NOTED

A monthly department dedicated as a forum for the interchange of ideas between readers and editors. All readers are urged to take advantage of this space and participate in the discussions presented.

Matrices for Electroforming

To the Editor:

Your excellent article in the July issue of MATERIALS & METHODS illustrating the art of electroforming precision metal parts neglected to mention one way of making matrices.

In your article you mentioned three possible techniques for making a matrix. One of these involves the use of a low temperature melting matrix having a melting point of from 200 to 500 F. For this purpose a metal spraying gun such as we produce can be used. Our gun melts and sprays low melting alloys with close control of the amount and characteristic of the spray. This same gun can be used in preparing molds for precision casting.

Michael S. Freeman

Metaloy Sprayer Co.,
New York 6, N. Y.

As Mr. Freeman points out, metal spraying should be included along with die casting, hobbing, or permanent mold and plaster mold castings.

—The Editors.

Dielectric Heating Equipment

To the Editor:

I notice in your MATERIALS & METHODS Manual #16, wherein you list processing equipment, that under the category of Furnaces and Equipment, Induction and Dielectric Heating, our name is not listed.

Inasmuch as we are one of the leading manufacturers of industrial dielectric heating equipment, and probably have more generators in actual operation in industrial plants than any other manufacturer, I am sure that in the future you would be interested in rectifying the omission.

Thank you very much.

Marion Taub

Radio Receptor Company, Inc.
New York 11, N. Y.

We appreciate having any omissions of this kind called to our attention so that future directories can approach perfection as far as accuracy is concerned.

—The Editors

Manual on Available Forms

To the Editor:

I second Mr. Alois' suggestion of July for a manual of available forms and supply of wrought materials—in fact—could make good use of it right now in preparing engineering standards.

H. B. Robinson

527 San Vicente Blvd.,
Santa Monica, Calif.

Other readers have indicated a desire to have published a comprehensive compilation of available wrought forms. Thus, we may prepare such a listing.

—The Editors

Engineering Societies Council of New York

To the Editor:

I am pleased to inform you that the new Engineering Societies Council of New York has been organized. Fourteen Engineering Societies have each appointed two delegates and two alternates. It was my privilege to be elected chairman. At this time, I would also like to tell you how much I really enjoy MATERIALS & METHODS. It is my duty to read at least ten different technical publications which come to me each month, and I am glad to say that yours is one of the three I really appreciate reading.

I am still amazed by the amount of factual data which you get into your publication each month, and compared to other similar publications it seems to me that you have at least three times as many technical articles which are worthwhile.

H. Carlson,
Chief Engineer

The Chas. Fischer Spring Co.,
Brooklyn 17, N. Y.

We appreciate Mr. Carlson's kind words and will continue to try to improve MATERIALS & METHODS. *It is for this reason that we recently conducted an editorial survey to see just what the readers want. Any readers not reached by our questionnaire are*

(Continued on page 669)

CONTENTS NOTED

Continued from page 667

invited to pass on their comments as to what they like and/or dislike about MATERIALS & METHODS.

—The Editors.

Supersonic Inspection

To the Editor:

Would it be possible for us to have two copies or reprints of the article, "Supersonic Inspection of Materials" by H. R. Clauser, pp. 379-384 of MATERIALS & METHODS for August 1946?

Elizabeth P. Hatch (Mrs.),
Librarian

Metals & Controls Corporation,
Attleboro, Massachusetts

No reprints of this article are available but tear sheets are being sent.

—The Editors.

Induction Heating Manual

To the Editor:

I compliment you on Manual #18 in your August 1946 issue devoted to the subject of Induction Heating. Would it be possible for us to have about ten reprints if they are available?

Do you plan to compile a collected coverage of the so-called Dielectric Heating field? I can well appreciate the fact that the almost endless scope of the non-metallic field should probably be subdivided, but am sure that a duplicate treatment in the excellent manner attained for Induction Heating would be indeed stimulating.

Thank you.

William G. Ellis

Radio Corporation of America,
RCA Victor Division,
Camden, New Jersey

As with other MATERIALS & METHODS *Manuals, #18 on Induction Heating is now available in reprint form. These reprints are sold at 25 cents a copy. As reader Ellis suggests, we are considering a manual similar to Induction Heating on the subject of Dielectric Heating.*

—The Editors.

Likes Appearance of Materials & Methods

To the Editor:

I have just seen the August issue of MATERIALS & METHODS, and wanted to write and tell you what an excellent job it is.

We receive a good many technical journals at this office, and the ones that combine attractive lay-outs with first-class articles are very rare. Your journal is a pleasure to look at, and extremely instructive to read.

John E. Pfeiffer,
Science Director

Columbia Broadcasting System, Inc.,
485 Madison Avenue,
New York 22, New York

Tool Steels

Since publishing the comprehensive MATERIALS & METHODS Manual on "Tool Steels" that appeared in our July issue, we have had our attention called to a couple of errors in type-classifications of some of the steels discussed.

Thus in Table 1 on page 121 the tool steels referred to as compositions 36, 37, 38 and 39 are not as clearly identified as they should be. No. 36 (the "Mo-Max" composition) and not No. 37 is the type M-1 steel; No. 37 is actually type M-10. No. 38 is merely a minor modification of No. 36, and is also a type M-1 steel. The type M-2 steel in the list is actually composition No. 39, not 38 as we had shown.

Elsewhere in the Manual it is implied that the composition 39 (or type M-2) steel is useful primarily because it conserves tungsten; actually this steel, originally developed as a conservation measure, is now a very worthy material in its own right and has become one of our most useful high speed tool steels.

Finally, on page 132, Table 22A, step No. 4 should read "heat to suitable hardening temperature;" the 2250-2300 F cyanide-hardening temperature indicated in the original Table is satisfactory for many high speed steels, but would result in serious overheating of others, for example compositions 36, 37 and 38.

—The Editors.

THE NEW G-E GAS

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These FIVE Important Advantage

1. Uniform, Accurately Controlled Carburizing—With exact control of temperature, time at temperature, and gas distribution, the new, electrically heated G-E gas-carburizing furnace assures a uniform, high-quality output of carburized steel.

2. Short Carburizing Cycle—Accelerated heating by means of a high-powered furnace, and uniform heat distribution by a circulating fan, appreciably shorten the carburizing cycle.

3. Low Operating and Maintenance Costs—Using an inexpensive carburizing gas, having a short heating cycle, and requiring a minimum of material-handling operations—the new gas-carburizer is economical to operate. With a sturdy construction and a convenient arran ment of components, furnace maintenanc reduced and simplified.

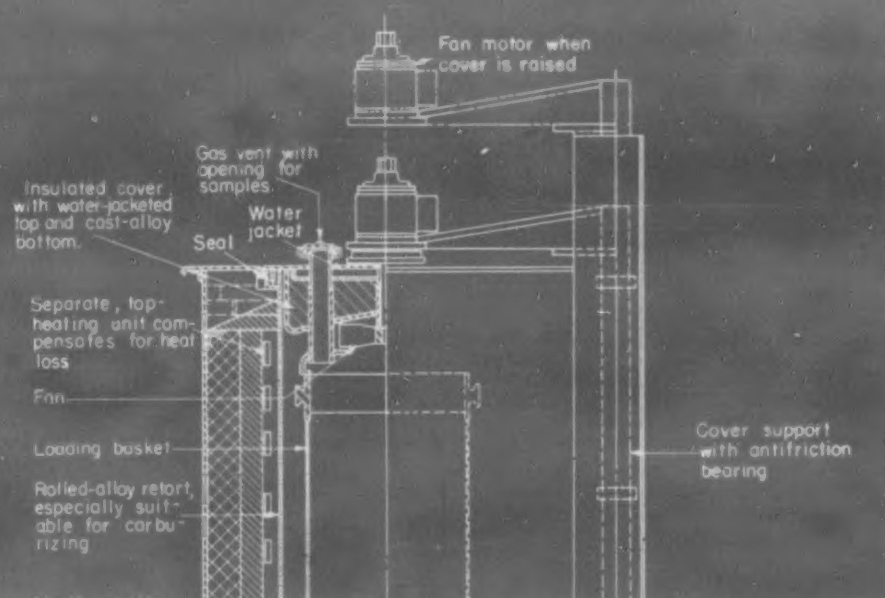
4. Simple, Accessible Controls are convenien provided on a single instrument panel.

5. Improved Working Conditions—With the eli nation of solid carburizing compounds, wo ing conditions are clean, and the gene appearance of the heat-treating room improved.

. . . And These Plus-dividen of Leadership:

- **Performance-proved Construction**
- **Technical Assistance**
- **Nationwide Field Service**

The new, standard gas-carburizing furna like all other G-E electric furnaces, assu you of performance-proved constructi based on steadily improved lines over alm a half-century of electric furnace resear design, and manufacture. To assist you in proving your product, experienced Heat Specialists are ready to help you to select y equipment and to recommend new, effic techniques. And, in major cities through the country, an expert field organizatio maintained to speed installations, solve op ating problems, and to be readily availa for servicing equipment.



NUMBER 120
September, 1946

METHODS: Testing

Identification of Electroplated Coatings

When undertaking the identification of an unknown electroplated coating, the examinations should be made in the order in which they appear in the table; often it will be unnecessary to make all five tests. The first four can be performed with little or local damage to the samples; test No. 5 usually is destructive.

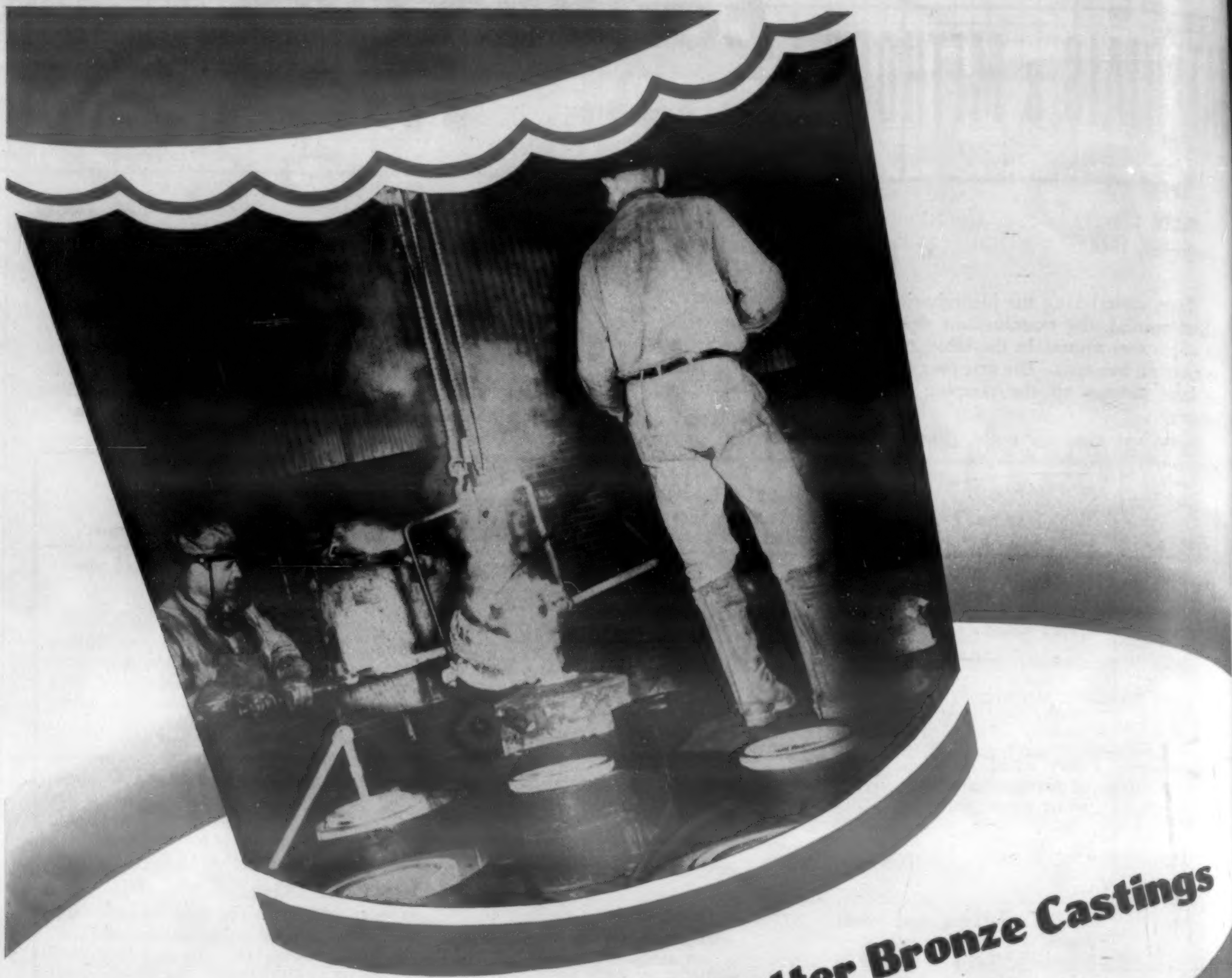
Before any tests are made, protective lacquer coatings must be thoroughly removed by the use of a solvent (*i.e.* lacquer thinner).

When making spot and other chemical identification tests for plated coatings, care must be taken to note that the reaction or color produced by the test is due to the coating and not to the basis metal. Thin or porous deposits may give false indications.

In the table below, the acids listed are concentrated unless otherwise stated.

Coating	Test No. 1 Color and Appearance	Test No. 2 Scratch Test for Hardness	Test No. 3 Spot Test With Concentrated Nitric Acid	Test No. 4 Spot Test With Concentrated Hydrochloric Acid	Test No. 5 Chemical Identification
Brass	Light yellow to reddish-gold	Soft	Dissolves — spot is blue or green color	Slight reaction	See tests for copper and zinc
Cadmium	Silvery white	Soft	Dissolves — spot is colorless	Dissolves — spot is colorless	Dissolve in nitric acid, make solution alkaline to litmus paper with ammonia, then add 10% sodium sulphide solution, a yellow precipitate indicates cadmium
Chromium	Frosty white in rough or matte finish; blue-white when polished	Very hard	No reaction	Dissolves — spot is green	Dissolve in hot 1:1 sulphuric acid, dilute after cooling, boil, add small amount of 3% solution of silver nitrate and add several crystals of ammonium persulphate; bright yellow color appears
Copper	Reddish, darkens and loses its luster on standing	Soft	Dissolves — spot is light blue (add drop of ammonia to spot — dark blue color appears)	Very slight reaction	Dissolve coating in hot sulphuric acid, dilute and immerse an iron nail (or steel knife blade) in solution; if copper is present, it will plate out on the iron or steel
Gold	Typical gold color (or may be slightly alloyed to give a reddish color)	Soft	No reaction	No reaction	Can be dissolved by sodium cyanide or aqua regia (1 part nitric acid plus 3 parts hydrochloric acid)
Lead	Dull, silvery	Very soft	Dissolves — spot is colorless	No reaction	Add 10% caustic soda solution until alkaline to litmus paper; a white precipitate appears
Nickel	Silvery white; when polished and compared with chromium, it appears yellowish	Hard	Dissolves in dilute nitric acid—spot is blue or green	Slight reaction	Dissolve in nitric acid, make the solution alkaline to litmus paper with ammonia, add small amount of 1% solution of dimethylglyoxime in 95% ethyl alcohol; pink or red precipitate appears
Platinum	Silvery white	Relatively soft	No reaction	No reaction	Can be dissolved by aqua regia (see gold)
Silver	Frosty white when unpolished; has high luster and bright characteristic color when polished	Soft	Dissolves — spot is colorless	No reaction	Dissolve in nitric acid, make solution alkaline to litmus paper with 10% solution of caustic soda; a brownish-black precipitate appears
Tin	Bright grayish-white	Soft	Dissolves in dilute nitric acid—spot is cloudy white	Decomposes	Dissolve in hydrochloric acid and add solid cacotheline (a nitro derivative of brucine); a reddish-violet color appears
Zinc	White	Soft	Dissolves — spot is colorless	Dissolves — spot is colorless	Dissolve in nitric acid, make solution alkaline to litmus paper with ammonia, add 10% solution of sodium sulphide; a white precipitate appears

Prepared from data furnished by George Black, Jack Sinner and the "1945 Plating and Finishing Guidebook" (Metal Industry Publishing Co., New York)



MATERIALS & METHODS Engineering File Facts

NUMBER 121
September, 1946

Heat and Cost Properties of Fuels

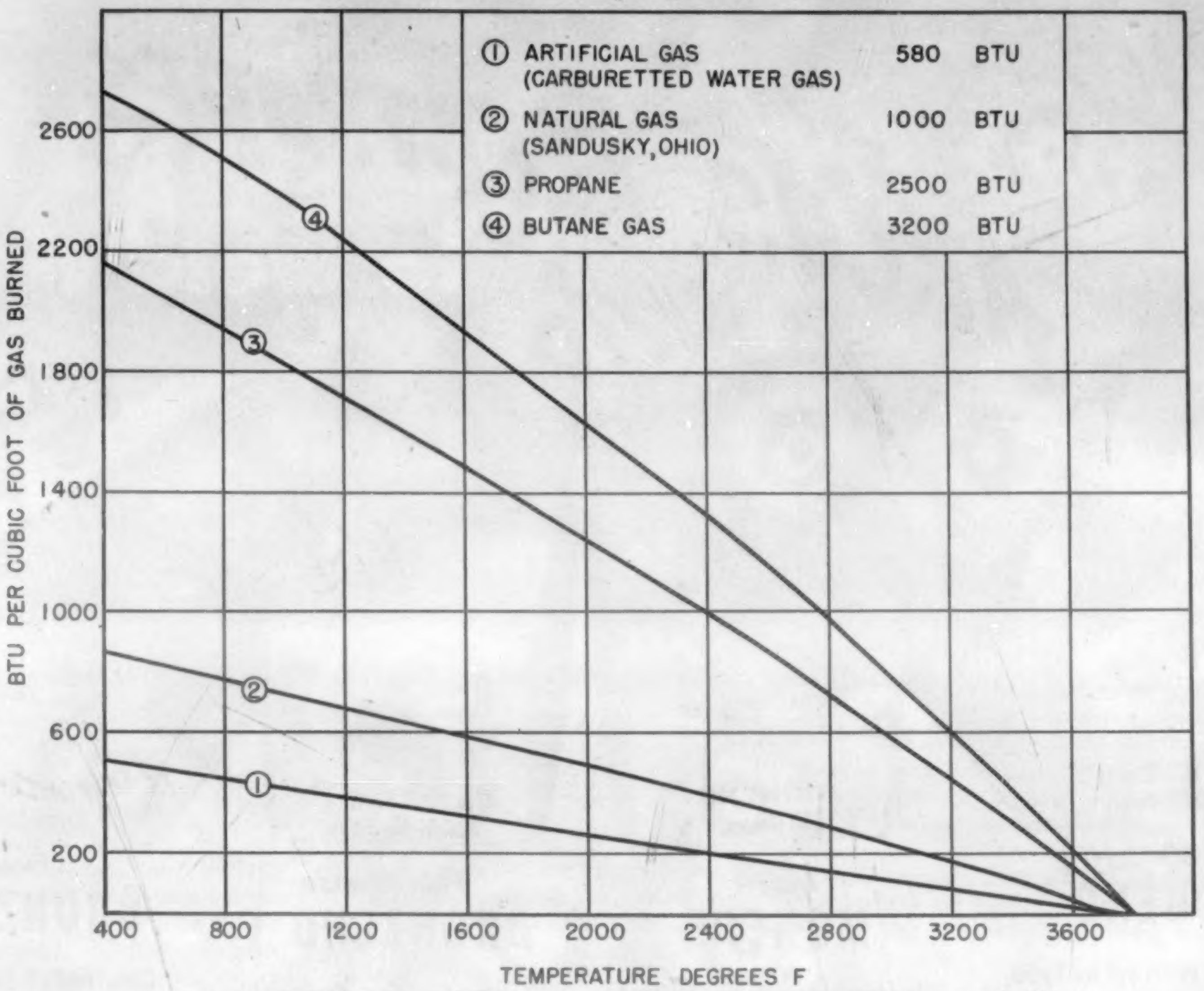


Fig. 1. Graph showing the heat generated by burning representative gaseous fuels.

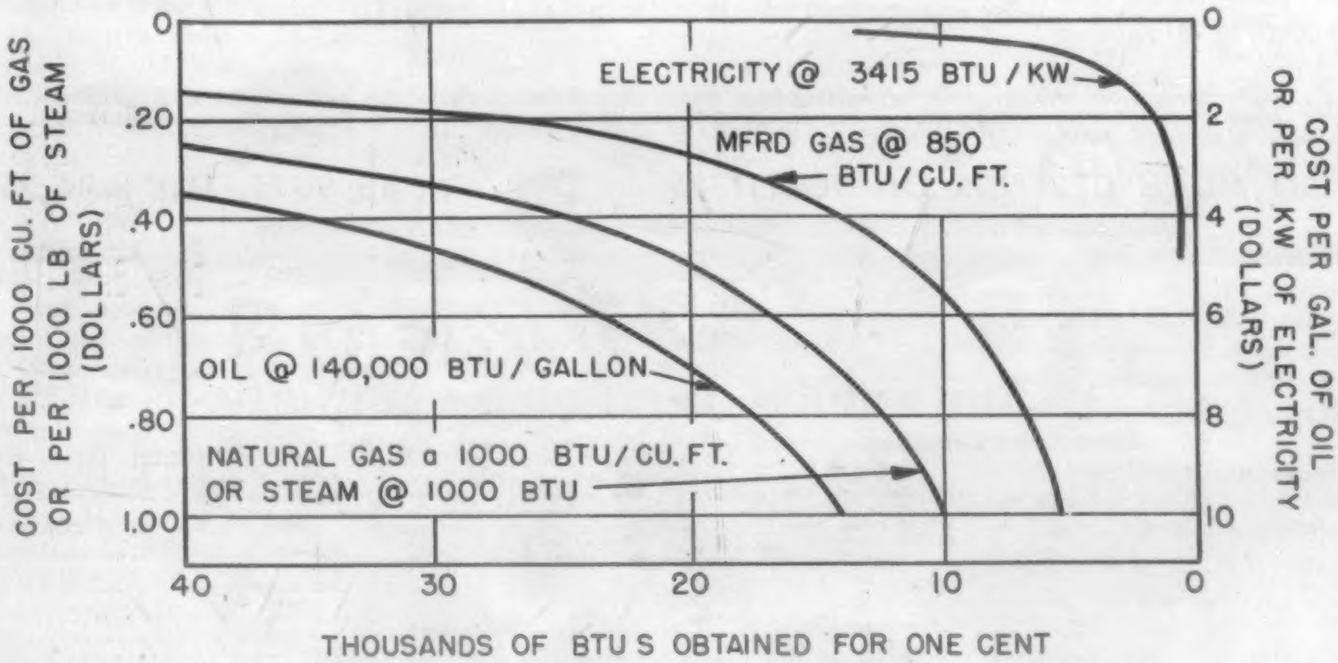


Fig. 2. Comparison of costs of oil, natural and manufactured gases and electricity.

Fig. 1. Taken from data supplied by Surface Combustion Corp.
Fig. 2. Taken from data supplied by J. O. Ross Engineering Corp.

engineering

SHOP NOTES

How to Build and Use a Preheating Furnace

by H. H. Moss,
Linde Air Products Co.

The most common apparatus for general preheating is a temporary firebrick furnace fired with charcoal. Such a furnace can easily be erected according to the following instructions. All that is required are the firebricks, some asbestos paper, and fuel.

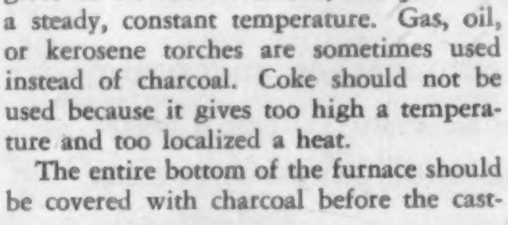
A temporary firebrick preheating furnace should be built to suit the individual needs of each job. Enough space should always be left between the brick wall and the casting to take care of the charcoal and to handle the casting if it is necessary to turn it during welding. A more accurate estimate of the dimensions can be made if the casting is temporarily placed in position for welding.

First, the furnace floor should be built with the bricks laid closely together on the concrete floor of the welding shop. A few shovelfuls of dry sand spread over the bricks will fill up the cracks. This prevents embers or drops of molten metal from accidentally escaping from the furnace and causing a fire, and further serves to insulate the shop floor from the heat. Next, the walls should be built, leaving a 2-in. space between the bricks at intervals on the first course to provide draft. The walls should be built up a bit higher than the top of the piece to be welded. Bricks, placed on end near each opening in the first course, act as dampers.

Finally, two bricks should be placed on edge on the top of the wall with a steel rod or light angle iron across them to serve as a support for the asbestos paper roof and to form a flue that will produce sufficient draft. If the casting is particularly heavy or cumbersome, it should be positioned on the furnace floor before the walls are built.

Charcoal is the most suitable fuel because it requires no forced draft to burn, gives off no soot or smoke, and produces a steady, constant temperature. Gas, oil, or kerosene torches are sometimes used instead of charcoal. Coke should not be used because it gives too high a temperature and too localized a heat.

The entire bottom of the furnace should be covered with charcoal before the casting is placed in the welding position. The casting should be supported on bricks or pieces of brick on the floor of the furnace. This is to prevent it from sagging under its own weight, to place the weld in a horizontal position, and to permit its being preheated from underneath. Then more charcoal should be strewn loosely all around the casting. Not too much charcoal should be used though, for it is likely to overheat the casting and cause it to sag or warp.



A sketch of a typical temporary preheating furnace. When the charcoal begins to glow evenly, the furnace should be covered with asbestos paper.

Since thin parts of the casting get hot more quickly than the thicker sections, more fuel should be placed around the heavier sections. When the charcoal begins to glow evenly, the furnace should be covered with a sheet of asbestos paper. To make sure that all the charcoal is thoroughly ignited, a blast from a compressed air hose can be introduced for a moment through the bottom draft holes. Do not use oxygen or the oxygen hose for this purpose.

The fire should be watched and regulated so that the part is heated uniformly. This means closing or opening draft holes, moving hot coals around, or adding fuel wherever necessary. To avoid overheating thin sections, fuel should be added only around the heavier sections. After the fire has burned for half an hour or more, it is time to check the temperature of the casting so that it will not become overheated. A flap-like break should be made in the asbestos paper.

There are several methods of testing the temperature, the most accurate of which is by using temperature-indicating crayons. If these are not available, however, a splint of soft pine can be rubbed

(Continued on page 679)

Announcing

TWO NEW SERIES OF MUREX ELECTRODES

...For All-Position Welding of High-Strength Steels

One of the most important welding developments in recent years, the new Murex line provides two complete series of chrome-moly electrodes especially suited for all-position welding of power plant piping and equipment as well as a variety of applications involving high tensile strength steels.

The graduated alloying contents of chromium and molybdenum give these electrodes a wide range of well-balanced mechanical properties. Thus it is possible to select weld metal similar in strength and ductility to many high tensile steels. The eight electrodes, listed at right, comprise the two groups.

	MUREX TYPE	AWS Grade
... for use on direct current with reverse polarity.	1100	E7010
	2110	E8010
	4110	E9010
	4210	E10010
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... for use on alternating current or direct current with either polarity.	1113	E7013
	2113	E8013
	4113	E9013
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MUREX ELECTRODES

inst the casting; if the wood chars, the t is ready for welding.

A more accurate test can be made by king a button from a small amount of d melted from a lead bar and placing on the casting. If the button melts wly, the temperature of the casting is out 600 F, which is the desired heat for linary cast iron. The two bricks on top the wall can then be removed to lower e asbestos paper for welding. A piece asbestos paper loosely folded three or r times can be placed on top of the nace to protect the operator from the at.

Improved Method for Making Fine Diamond Dies

A method for making fine diamond es, 0.0004 to 0.015 in. in size, in ughly one-third the time required by evious European and American meth-ls, has been developed by The Bureau Standards, Dept. of Commerce.

The European and American die mak-s customarily used a star drilling action making diamond dies. This called for drilling machine with a horizontal, ngle spindle making 3,500 rpm. The achine carried a sewing needle for the ill. The diamond, mounted on a sec-d spindle, oscillated against the sharp-ed end of the drill. Frequent regrind-g of the needle was necessary. The ethod was tedious and took from 115 170 hr. to produce a die of 0.001 in. r less.

Use of electric current in the drilling ocess is the chief innovation developed the Bureau of Standards. The equip-ent consists of a variac, rheostat trans-rmer, alternating current ammeter, uenched spark gap, and a support for e diamond and electric drill.

To form the primary cone, a pilot hole foredrilled through the diamond by eans of an electric spark. Then, by orking through the pilot hole with a ght commercial drill, the contour of the ne can be reamed or shaped without lling the drill. The operation takes bout 3 hr. for one die.

Drilling of the secondary cone, also one electrically, takes 1 hr. Thirty hr. is nsidered necessary for finishing and pol-hing the secondary cone and bearing. revious methods have not given suffi-ent emphasis to this phase of the work. However, polishing is done with a mul-ple head drilling machine, operating 24 r. a day and requiring scant attention, that the cost per die is small.

Altogether, with the methods used by e Bureau of Standards, a die can be ade in about 40 hr.

Another objection to the foreign die-akers' practice is that of bruting-cutting ne diamond with another to form par-llel surfaces. This practice results in rain, flaws, or fractures in the die. *(Courtesy, Office of Technical Services, J. S. Department of Commerce.)*

Preventing Magnesium Fires

by Norman J. Thompson, Associated Factory Mutual Fire Insurance Companies

Proper spacing and arrangement of magnesium stock plus standard automatic sprinkler protection are the most dependable safeguards against high losses from magnesium fires. This is one of several important conclusions coming out of a series of sixteen fire tests recently undertaken by the Factory Mutual Laboratories. The tests were conducted inside a building, and the purposes were to disclose the burning characteristics of the metal and to re-examine protective recommendations.

It was demonstrated that the water from automatic sprinklers absorbs a large proportion of the heat from a magnesium fire and reduces the general temperature

One ton of magnesium chips burning during fire test at Factory Mutual Laboratories. Water from six sprinklers protects building against structural damage.

in the room. This occurs despite the fact that the water intensifies the burning and hastens the destruction of the pile. The general room temperature is less under sprinkler discharge than if the fire is allowed to burn without any attempt to extinguish it.

Sprinkler protection was also shown to be capable of confining a fire to a single pile, and to prevent structural damage to buildings and to ordinary combustible material as close as 5 ft. to a fire involving 150 lb. of magnesium. Without sprinkler protection, a fire involving the same amount of magnesium will ignite combustibles at a lateral distance of 10 ft., and at considerably greater vertical distances.

Even when well away from walls and partitions, a fire in 600 lb. of castings, and probably considerably less, would cause ultimate complete destruction of an unsprinklered and otherwise unprotected plank-on-timber building. Other piles of magnesium castings 4 ft. away from such a burning pile would not become involved if under sprinkler protection.

Burning magnesium on contact with concrete causes violent spalling, which scatters the fire. A similar explosive action occurs when molten magnesium drops into any pools of water which may collect on an uneven floor. Both of these factors contribute considerably to the violence of a magnesium fire but can be largely eliminated by covering the concrete with a sufficiently thick layer of porous, noncombustible material, such as sand or cinder.

Storage in a basement or similar subgrade space should be avoided because of the difficulty of venting and relieving pressures produced by contact of water with molten metal and by explosions in hydrogen-air mixtures. Storage on grade floors with no space below is advisable. Based on extent of floor damage in the tests involving only a ton of magnesium, it is probable that fires in larger quantities would produce holes, even in a reinforced concrete floor, and permit burning metal to drop through.

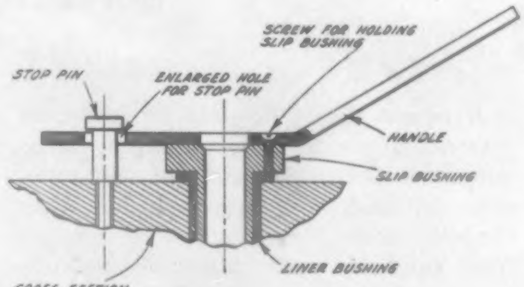
Slip Bushing Handle

by Thomas A. Dickinson

When varied-diameter holes must be drilled in a single article with a single jig, it is ordinarily a time-consuming procedure, because the bushings must fit into the jigs with reasonable tightness and because there is generally no way to insert or remove the bushings with reasonable efficiency.

Therefore, much time can be saved in many factories by means of the slip-bushing handle, as shown in the drawing. It can be readily made from scrap-metal plate, and it is fastened to the slip bushing by means of a single screw. Because a simple stop pin will prevent rotation of the handle and bushing during drilling operations, the bushings used may fit loosely into the liner — thus permitting rapid insertion and removal by simply grasping and turning the handle.

Dimensions of the handles depend primarily on the sizes of the bushings that are to be used. However, they should be standardized to such an extent that they will not necessitate varied stop-pin locations. One handle should be made for each bushing that is to be used in drilling a single hole.



Drawing of the slip-bushing handle showing its essential features.

Preparing Bearing Shells for Babbitting

by A. A. Goodman,
Westinghouse Electric Corp.

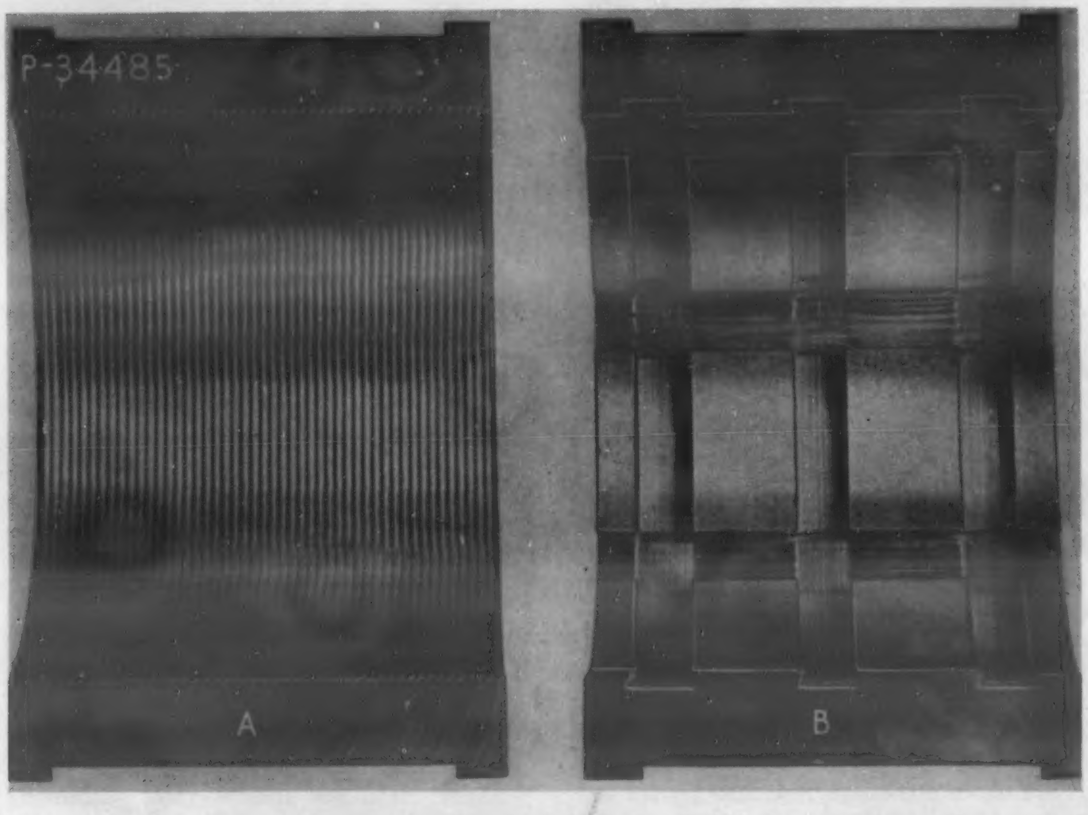
Years ago, when the predominent number of large babbitted bearing shells were made of cast iron, a series of axial and circumferencial dovetailed slots were cut into the bore of the shells prior to pouring of the babbitt lining to the shell.

In the transition from the use of cast iron to steel and bronze shells which would bond to babbitt, these slots were dispensed within the smaller sized bearings. The larger bearings, however, regardless of material, still carried the slots as an additional factor of safety against the change of having the babbitt lining loosen away from the shell.

Early in the last war, the importance of saving man and machine hours, plus the critical shortage of tin, resulted in the acceptance of a shop suggestion to replace the slots with a serrated bore. Such a bore would present more surface for the babbitt to bond to than a smooth bore. A 12-pitch serration was decided upon which gives approximately 50% more surface per linear in. than a smooth bore.

The saving in babbitt that formerly filled these slots was considerable and the saving in man and machine hours was indeed welcome. The slotter operation (axial dovetails) was completely eliminated, and the entire bore is finished on the lathe or boring mill on one setup.

This serrated bore is now used on all bearings except those made of cast iron and aluminum bronze, which will not bond to babbitt without special salt bath treatments or without the use of electroplating.



The old and new way of preparing bearing shells for babbitting. A shows the serrated form now in use; B shows the old type dovetail slots.

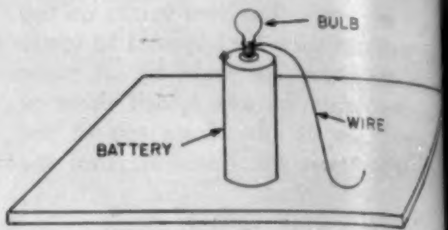
Spot-Checking Anodic Films

by George Black

It is not always possible to detect the presence of anodic films, and often an assembly workman or inspector will question the finish of a part in hand. Light chromic acid films and those applied from sulphuric baths can easily be mistaken for bare metal. With the visual test so uncertain, it is important that all concerned be aware of the relatively simple methods available for spot checking.

Since unanodized aluminum forms a comparatively weak bond for paint films, the ease with which paint coats can be stripped is usually a fair indication as to whether or not the surface of the metal had been treated prior to painting. This is not considered trustworthy, however, as too much variation will be encountered according to the type of paint used, the method of application, the thickness of the coats, the type of cleaning solvent being used, etc. Actual testing of the film begins after the surface has been solvent cleaned down to the bare metal.

Using regular stamping ink, apply a stamp impression to the cleaned surface



Sketch showing a simple set-up for electric spot test of anodic films.

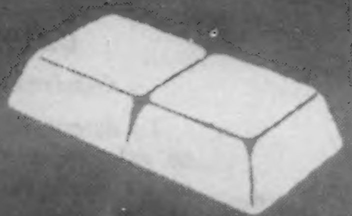
and allow to dry, then rub briskly with a dry clean cloth. Chromic acid anodic films will retain the stamp impression while bare metal or sulphuric acid films will permit the impression to be wiped away. If the ink impression remains it is a fair indication that an inorganic surface treatment has been applied. This ink retention test should be followed by an electric spot test if the stamp impression wipes away, or if further proof of the existence of a chromic acid film is desired.

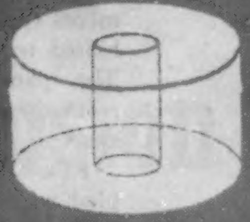
All kinds of elaborate equipment can be used to test the dielectric value of the anodic film, but all that is needed is an ordinary flashlight battery and bulb, and a piece of wire. The surface to be tested should be thoroughly cleaned, using solvents and rags only; then the tester should be rigged as shown in the accompanying illustration.

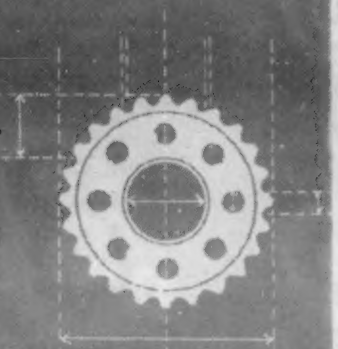
With the base of the battery in contact with the bare metal surface, the free end of the wire is held against the metal. It is recommended that the free end of the wire be bent up so that contact is made with the radius of the bend rather than with the edge of the wire. Care should be exercised to prevent scratching the metal.

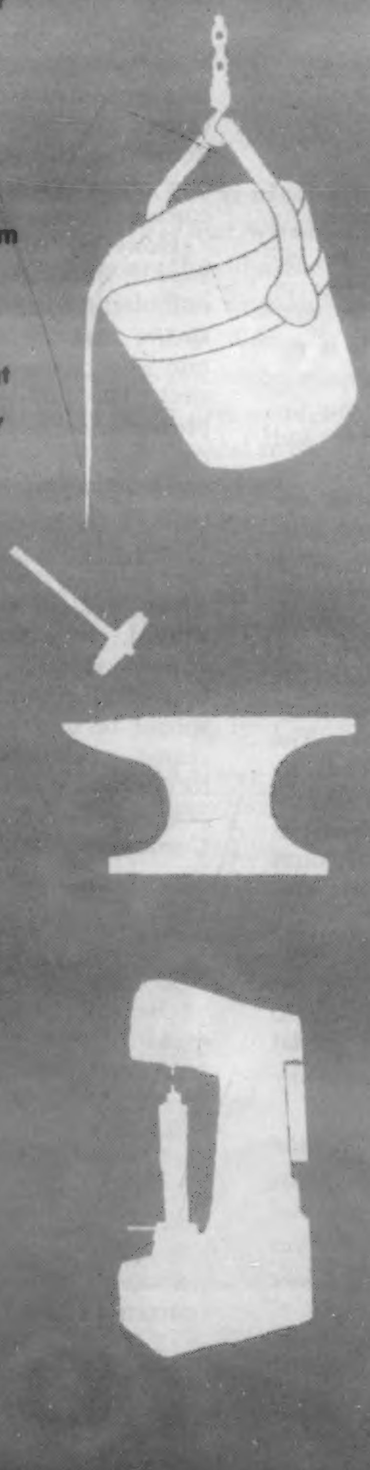
Unanodized aluminum will conduct the current and make the bulb glow immediately. Surfaces anodized by the chromic acid method will prevent the passage of current under ordinary pressure contact, while anodic films formed in sulphuric baths show excellent strength and require heavy pressure and scratching before current will flow.

Improved performance of timing motors when operating under an extremely wide range of temperatures with the use of silicone oil as a lubricant has been reported by the Hayden Manufacturing Co., Forestville, Conn. According to engineers, the improved operations resulted from the properties which are peculiar to silicone oils. In addition to withstanding high ambient temperatures, the oil does not readily oxidize or corrode. It does not react with any of the more common metals, has a very low volatility loss, and has a relatively flat viscosity curve. (General Electric Co.)









MATERIALS & METHODS DIGEST

A selection of outstanding articles on engineering materials and processing methods in the metal-working industries.

MATERIALS and DESIGN

Metals and Alloys

Nonmetallic Materials

General Product Design

METHODS and PROCESSES

Melting and Casting

Fabrication and Treatment

Testing and Inspection

METALS and ALLOYS

Engineering properties and applications of carbon, alloy and stainless steels, irons and nonferrous metals and alloys. Selection and evaluation of metallic materials for engineering service. New alloys and modifications.

Magnesium Battery

Condensed from "Light Metals"

Magnesium cells were invented by Gordon in 1930 and later developed into a practical and serviceable battery at the works of Callender's Cable & Construction Co., Ltd. (England). In their simplest form these cells were produced in three sizes, the smallest 5 in. long by 2 in. dia., consisting of a carbon tube (the anode forming the body of the cell), with three magnesium rods 4½ in. by ⅜ in. wrapped in woodwool and inserted in the tube to form the cathode.

The cell gives an unvarying current of 1.5 volts during 400 hr. continuously or 1 volt at 100 milliamps under load. Neither temperature nor current output vary 5% until the magnesium is exhausted. The next size, 5 by 2½ in., containing five magnesium rods as cathode, gives 600 hr. continuous output without current drop or temperature rise.

The third size, 5 by 3 in., with eight magnesium rods, gives the same voltage and ampere output for 1000 hr. The cell weights range from 8 to 15 oz. The permissible rate of discharge depends entirely on the cathode surface exposed to the action of the electrolyte and can be calculated by the designer as closely as the output of secondary cells.

The electrolyte is merely aerated water, with no waste of the metal element, provided air and moisture are not present in large quantity. The cell does not deteriorate by storage, even in the tropics, if kept dry. By decreasing internal resistance and increasing air the large cell may be exhausted in 400 hr. at a discharge rate of 1 volt 334 m/amp.

Logical application for these cells is for domestic purposes, such as for lighting in remote districts with no electric supply; also for propelling road, rail, river and light sea-going transport. The batteries can be recharged. One item undergoing endurance test is a domestic refrigerator unit, including a compressor blower and prime mover, consisting of two pairs of solenoids in place of an electric motor for propulsion, powered by 24 to 48 3-in. cells.

Also a submersible pump, operated by two solenoids, actuated by a Gordon magnesium battery, is undergoing test. The number of cells needed here depends on the bore of the delivery pipe and on the height the liquid must be lifted from its source to the delivery point. A magnesium "deaf aid" battery of pocket size has also been tested.

In testing there is a certain delay before the cell reaches full voltage; on intermittent work this induction period may amount to as much as 30 to 40 sec. and, after partial evaporation, may be still greater, caused by the quality of the carbon tube. By eliminating all ash content from this carbon the full voltage was developed immediately, except when the cell has been in use and allowed to dry up, or when first put into service. (*Light Metals*, Vol. 9, July 1946, pp. 354-355.)

Corrosion Protection

Condensed from "Corrosion"

To determine the real effect of painting on galvanic corrosion, a number of experiments were made at Kure Beach, N. C. Marine exposure was selected for the test because galvanic corrosion is most severe in salt water.

The metal couples used in these experiments consisted of a low carbon steel panel bolted to a copper panel of the same size. The panels were sandblasted and then painted according to five different paint systems.

Results show that when bare steel is coupled with an equal area of bare copper the corrosion rate of the steel is increased by a factor of 2-3. If the steel is painted and the copper left bare, the corrosion rate of the steel is decreased markedly, and the decrease depends upon the individual coating system used. If the steel is left bare and the copper is painted, the steel corrodes at its normal, or uncoupled rate, and if both the steel and the copper panel are painted, corrosion is essentially prevented.

It should be noted that although painting only the anodic areas may result in reduction of the actively corroding area, there may be a marked increase in the intensity of the attack, and thus this prevalent method should be regarded as unsafe practice.

In another series of experiments the authors attempted to determine the corrosion rate of bare steel panels coupled to imperfectly coated copper cathodes. The data presented show that painting only the copper portion of steel-copper couples reduced the corrosion rate of bare steel to that of uncoupled bare steel, when the coating coverage was complete.

However, when small areas of copper were intentionally left bare, the corrosion rate of the coupled bare steel member was, in the majority of cases, greater than the rate when bare copper was coupled to bare steel. This finding was unexpected and the phenomenon cannot be explained at present.

These experiments show that the selection of a satisfactory protective coating should not be made solely on the basis of the paint system, and that the structure which is to be coated should also be considered. It is the safest practice to paint both anodic and cathodic areas with the best alkali-resistant paints available. Care should be exercised to avoid pinholes, uncoated edges, faying surfaces and similar foci for localized galvanic attack. (G. W. Seagren, G. H. Young & F. L. LaQue. *Corrosion*, Vol. 2, June 1946, pp. 67-77.)

Zinc-Base Die Material

Condensed from "Modern Metals"

One of the many new alloy developments exploited to good advantage during the last few years was "Kirksite A" for various types of tooling. The material is a zinc-base alloy produced by the National Lead Co.

First thought of as a medium for temporary tooling, it has been found in many cases that "Kirksite A" can be used for permanent tooling. Almost every aircraft concern in the United States and Canada

produced tools of this material. There are definite indications at this time to substantiate the opinion that the alloy will be widely used in this and other industries.

Tools made and used most successfully with "Kirksite A" are three-piece form dies for mechanical presses, two-piece dies for press brakes, drop hammers, stamps and bulldozers, as well as one-piece dies for stretch presses. In addition, such tools as blank and pierce dies, bending and joggling dies, form blocks and holding fixtures, have been found practical. There is just no end to its use in post-war tooling.

One of the advantages of "Kirksite A" is the fact that it is reclaimable. The tool produces the part, and when part obsolescence occurs, the tool is melted down and recast as another tool. It is not intended as a panacea, a substitute for steel dies. It cannot be expected to replace steel in all its established applications, but in many cases it has been found more economical to use several "Kirksite" dies on one job rather than one steel die.

Some of the physical properties of "Kirksite A" as sand-cast are shown in the following table:

Compressive strength	60,000 to 75,000 lb. per sq. in.
Shear strength	34,000 lb. per sq. in.
Melting point	717 F
Specific gravity	6.7
Weight per cu. in.	0.26 lb.
*Elongation—sand-cast	3% (in 2 in.)
Coefficient of linear expansion	$15.4x10^6$ per F
Electrical conductivity	24.9% of Cu
Thermal conductivity	0.24 calories per cubic cm. per C at 18 C

* *"Kirksite A" in rolled form has an elongation of 30% in 2 in.*

Other tables given show comparative costs between "Kirksite" and steel tooling, life data for "Kirksite A" for various operational material, and physical properties of "Kirksite A" in comparison to cast iron and sand-cast aluminum. (W. W. Richmond. *Mod. Metals,* Vol. 2, June 1946, pp. 21-22, 24.)

Improved Chromium Plate

Condensed from "Metal Industry"

The use of electrodeposited chromium for repair of worn machine parts or the protection of new components is now recognized as a valuable aid to the engineer. A considerable volume of work is "flash" chromium-plated to thicknesses of from 0.00003 in. to 0.00006 in. because heavier deposits fail to adhere with the base metal sufficiently to resist the effects of "heavy-duty" work. The method discussed by the author is one in which two chromium baths are used to provide a composite deposit comprising a "soft" adherent and impact-absorbing under-layer and a very hard wear-resisting outer layer.

It is found that plain carbon steels submit the most readily to chromium deposition and provide the best base upon which to obtain a useful degree of adhesion. They are usually ready for deposition after pickling, surface smoothing treatment and

a very short acid electro-etch. The ne important influence upon the life of the chromed component is the hardness and wear resistance of the deposit, and the structure of the chromium deposit is dependent upon the nature and control of the electrolyte.

It is a common practice when chromium plating difficult base alloys in the standard chromium bath to "strike" the work at high current density at the commencement of the deposition and subsequently to reduce the current to normal. This practice produces a soft initial deposit upon which is built up the greater thickness of hard chromium.

Such deposits have an unnecessary low resistance to distortion and impact, partially because the initial deposits produced by the strike are highly stressed, brittle and crumbly at the cathode extremities. The composite deposit is greatly improved by selecting a softer under layer that will provide reasonable resistance to pressure.

The procedure is to plate the component first in the iron-chromium bath and after a given period of deposition, rinse in a spray of hot fresh water to remove all traces of iron, and transfer quickly to plate in the standard hard bath. The claim made in respect to the two-bath composite deposit is that a deposit consisting of soft and hard chromium using two separate baths as described has a greater resistance to the effect of impact, pressure and heavy wear than that of a similar thickness of either quality existing by itself upon a similar base metal. (A. L. Peach. *Metal Industry*, Vol. 69, July 5, 1946, pp. 14-16.)

Nitriding Steels

Condensed from "Iron and Steel"

Nitriding tests were made on various as quenched steels at temperatures from 900 to 1100 F for 48 to 144 hr. with 30, 45 and 60% dissociation. The maximum case hardnesses found after nitriding 144 hr with 30% dissociation were:

Grade	Vickers Hardness*	Nitriding Temp. F
1020	400	900
1095	425	900
9440	520	950
8630	540	900
8640	600	950
4130	625	900
Nitralloy G Modified	880	950

*based on microhardness, corrected to compensate for elastic recovery.

The Nitralloy G Modified was markedly superior in its response to nitriding both in respect to effective case hardness and case depth. The response of the other grades to nitriding was slight; therefore nitriding these steels does not appear warranted in most cases.

There was a fair agreement between superficial Rockwell hardness readings and the corrected microhardness values. The latter was believed preferable since the former may be affected by case depth, core hardness and microstructure. (P. A. Hawthorne. *Iron and Steel*, Vol. 19, Apr. 1946, pp. 142-146.)

BUNKER HILL

. . . the "practically lead-free" zinc

Even more important to the users of Special High Grade Zinc than the 99.99% minimum Zn content is the analysis of what's left. Lead, the element which causes so much concern to die casters and other metallurgists, is almost non-existent. For all practical purposes, Bunker Hill Zinc may be said to be "lead-free".

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NONMETALLIC MATERIALS

Design-uses of plastics, plywood, fibre, glass, rubber, ceramics, etc. as engineering materials. Composite metal-nonmetal combinations. New forms of nonmetallic materials.

Plastic Lenses

Condensed from "Plastics"

A British company announces its preparation to manufacture plastics spectacle lenses and two American companies reveal the extensive progress made in government sponsored wartime research in this field. Thus unfolds the story of the international race to mass produce the low-cost plastics spectacle lens.

Prior to the war, nearly every optical manufacturer with research facilities was engaged in the investigation of plastics for this purpose. With the outbreak of hostilities most of this work was stopped, but due to the need for speeded-up production of military lenses, it was undertaken at Polaroid Corp. and California Institute of Technology.

At Polaroid, 113 plastics were evaluated preliminarily; 17 were given extensive tests; and two finally proved suitable for precision optics. These are polystyrene and polycyclohexyl methacrylate (CHM), which belongs to the same family as Lucite. The former resembles flint glass optically; the latter crown. On a rating scale which has 100 points for a plastic of perfect physical properties, CHM had 84 points and polystyrene 79.

Lenses made of these plastics are said to have optical qualities similar to glass lenses except that the ultraviolet transmission is better, and the scatter of light falling normal to the surface is less.

Low scratch resistance of the surface, common to all plastics tested, was remedied to a practical degree with polystyrene and CHM by a process developed at California Tech. A hard film is deposited on the surface by exposing the lenses alternately to water vapor and a mixture of silicon tetrachloride and ozone. This makes the surface 20 to 30 times more resistant to wear.

Special tests, including abrasion, wear, scratch and temperature affect, had to be developed for evaluation of deposition film. Over-hard films were found to craze. Quantitative hardness limits were established.

Development of molding techniques at Polaroid entailed a refinement of earlier finding by the British that only casting without application of pressure would produce good surfaced and low internal-stress lenses. The Polaroid method polymerizes the plastic in the mold and compensates accompanying shrinkage with thermal expansion, produces lenses requiring no polishing.

Mold surfaces were made by optically grinding and polishing stainless steel blanks, or by electrodepositing metal on glass.

Procedure for manufacturing glass spectacle lenses is outlined, and compared with that for plastics lenses. The plastics process is shown to have many advantages.

It is admitted that glass lenses are produced in thousands of combinations, whereas plastics lenses must be made in a few hundred, in order to keep mold investments down to a practical level. Proponents of plastics lenses argue that 400 to 500 molds can supply from 60 to 70% of all prescriptions. To meet demand for today's odd shapes of frames, lenses may have to be produced oversize, and ground to fit frames. (P. Pollack. *Plastics*, Vol. 4, May 1946, pp. 27-30, 110-113, 115.)

Welding Thermoplastics

Condensed from "Transactions of the Institute of Welding"

Welding of plastics is one of the more recent developments in the field of joining materials. Only the thermoplastic materials, those which repeatedly soften under heat and solidify again, can be welded. Thermosetting materials cannot be welded. Hot gas, high frequency, heated tool, friction and flame welding are the welding methods suitable.

Materials which have been investigated for their welding behavior are: cellophane, celluloid, methyl methacrylate, polyamide (Nylon), polyisobutylene, polystyrene, polythene, polyvinyl chloride and its copolymers, polyvinylidene chloride and Thiokol. Particularly where larger structures are concerned, welding is cheaper than molding as the molds would be too expensive and the number of rejects unduly large.

Hot gas welding offers the widest scope. It closely resembles the gas welding of metals except that a jet of heated gas is used instead of flame. Filler rods are used the same as for metals, and technique and type of joints are much like with metals.

Gases are usually nitrogen, carbon dioxide or compressed air. The deposit bonds on the surface only, in contrast to permeating the parent metal. The strength of the gas welded joints does not reach that of the base material, but 80% strength is perhaps average.

High frequency welding is next in importance. The currents passing through insulating materials induces energy losses which appear in the form of heat. The currents are of the order of 5-100 megacycles, and are applied by an electrode system forming the two plates of a condenser.

One method is seam welding by a pair of rotating rollers which form the electrodes of a high frequency circuit. While the material is traveling between the rollers progressive spot welding occurs. Another method entails heating of a larger area under pressure. Plastic tobacco pouches are often thus welded.

Various types of heated tools comprise less important means of welding. Often rollers are heated by electrical resistance, but only fairly thin sheets can be thus welded. Electrical breakdown of the material cannot occur, but the temperature must be controlled so as not to overheat.

A method originated in the United States for joining tubes consists of pressing the pipe ends against a nickel-plated hot plate until they become soft and plastic; then withdrawn from the plate and butted together under pressure.

In friction welding the friction causes the necessary heat. For some materials an ordinary lathe is sufficient, provided the tailstock has a live center with a chuck. The two ends of the pipes are clamped into one chuck each and the lathe set going. The tail stock chuck is held by hand so that it cannot rotate.

In exceptional cases a finely tipped flame can be used for welding thermoplastics such as polythene sheets. Much plastic packaging during the war was welded air tight. (G. Haim & H. P. Zade. *Trans. Inst. Welding*, Vol. 9, Apr. 1946, pp. 51-53.)

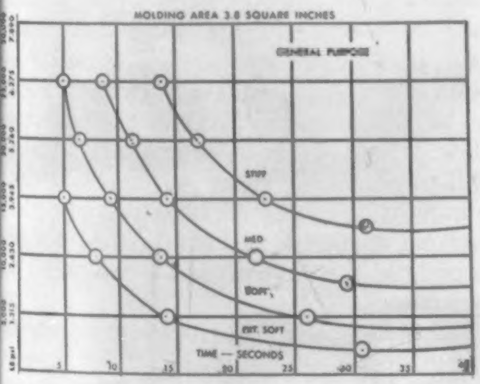
ENGINEERING DATA ON PLASTICS

5. MOLDING PRESSURE

Mold or molding pressure is the pressure which is exerted on the material within the cavity and on the projected mold "land" area. Pressure is often a deciding factor in the efficiency of production and hence one of the important factors in the initial engineering of the mold design and in selection of equipment.

Pressure Range

Generally the pressure range for compression-molding the various types of phenolic materials is between 1,000 and 10,000 psi. This, however, is a rather large range, especially when prompt and definite decision must be made for each specific material. In many instances insufficient pressure is provided, necessitating the use of softer materials or in some cases operating the mold with fewer cavities.



Various methods for figuring the required molding pressures are used. The basic figure consists of 2,000 to 3,000 psi on the mold "land" projected area. This pressure is considered sufficient to mold an object using general-purpose material up to 1" in depth; 700 lbs. being added for each additional inch of depth.

Example: If the available pressure for a particular mold is 2,500 psi, we would select the "soft" material which has closed in 13.5 seconds at 2,630 psi in the test cup mold as illustrated on the curve chart. Of course, this pressure is suitable for a part 2" deep. When molding a part 1" deep or less, the same material can be molded at 2,000 psi or medium material can be used.

Proposed A. S. T. M. Cup Method

Using the proposed A. S. T. M. cup method to determine the plasticity or mobility of any type of phenolic material, it is possible to select definite molding pressures with a close degree of accuracy.

It is recommended that the results obtained in testing the mobility be used as basic figures to determine the required molding pressures. The depth of the mobility test cup is actually 2.200". However, since the test mold has a definite .006" clearance on the flash land, it requires less pressure at the closing point than a mold which has a positive land at the flash point. To compensate for this difference a 2" depth is used for the basic figure. When molding anything from flat to 1" in depth, subtract 700 lbs., and over 2" depth add 700 lbs. of pressure for each additional inch of depth.

Calculating Molding Pressures

For calculating compression-molding pressures, let us assume that we are to mold an object of 8 sq. in. including the mold land area. The required pressure for the particular material is 3,000 psi. Hence, 8x3,000 = 24,000 lbs. per cavity. The available press has a 12" diameter ram and a fluid pressure of 2,500 lbs. Hence, 12x12x.7854 = 113x2,500 = 292,500 ÷ 24,000 lbs. = 12. Thus a 12-cavity mold should be constructed.

Free Pamphlet

We have prepared a detailed pamphlet concerning molding presssures and how to determine them. We shall be glad to forward copies on request. Durez Plastics & Chemicals, Inc., 99 Walck Rd., N. Tonawanda, N. Y.

Lignum-Vitae Bearings

Condensed from "Western Machinery and Steel World"

Lignum-vitae, a wood, is used as a bearing material in marine installations. It is a product of the guaiacum tree, or Brazil wood, and is found most abundantly in the West Indies.

The wood contains about 26% resin by weight, thus will not swell in water and there is no change in dimensional surfaces. Water is therefore used as the lubricant and coolant for the working surfaces of metal against wood. It has a specific gravity of 1.33 and sinks in water. Owing to the peculiar arrangement of its fibers, having almost no grain characteristics, it will not split.

The finished steel face plate of the gudgeon, serving as a rudder carrier, is bushed vertically with a sleeve of lignum-vitae to take the brass capped pintle which locks the rudder to the gudgeon. This lignum-vitae bushing, the stationary part of the bearing, is machined from a solid block of the wood. (*Western Machinery & Steel World,* Vol. 37, June 1946, p. 121.)

Properties of Wood

Condensed from "Mill and Factory"

The dimethylolurea (D.M.U.) process, developed by S. S. Keeley & Sons, Manayunk, Philadelphia, for treating wood improves the workability of various species. This discovery is important in industry because wood is the easiest material to fabricate with simple tools and is our only self-renewing and continuously obtainable raw material.

The process imparts up to 30% greater hardness and stability to any wood susceptible to treatment by it, and greater resistance to separation of fibers. Many small tool parts, especially handles, are made of D.M.U. treated woods.

The process increases the dielectric properties of woods and reduces the static that otherwise is usually produced by rubbing various metals together, and will not abrade the material being handled. Another result is the increased resistance to chemicals.

Woods excellent for treatment are: yellow, Penderosa and white pine, dogwood, boxwood, bass, poplar, maple, ash, Canadian spruce, elm, cottonwood, gums, various maples, and beech. Often the sapwood is highly treatable but not so the heartwood.

D.M.U. treated woods have been tested favorably for holding power by repeated pin driving tests, and also have proven superior over untreated woods in retaining this holding power for a much longer period of time. The process increases stiffness with shear resistance. The treatment can add color, but cannot subtract it; not all colors are practical at the present time.

Mechanical fabrication of finished parts is easy and profitable, the transverse strength of the cohesion of woods being greatly increased, and some ordinary milling processes may be eliminated. D.M.U. is also beneficial as an inspection method of testing woods. (E. L. Cady. *Mill & Factory,* Vol 39, July 1946, pp. 104-107.)

GENERAL PRODUCT DESIGN

Selection, applications and design of parts made by various fabricating methods or made of special materials. Properties and uses of finishes and coatings. Design and materials for specific products or fields. General engineering design trends or principles.

Nonferrous Forgings

Condensed from "Steel"

Nonferrous forgings are metal shapes produced by hot-working nonferrous metals, subjecting them to hammering and pressing operations. The result is the compression, bending, twisting, indenting or extrusion of the metal so that various parts of the forging are formed by pressure against dies.

Die-pressed or hammered forgings offer an efficient and economical method of producing irregularly-shaped metal parts from slugs cut from ingots or rods. The result is a strong, dense metal part, closely resembling the shape and size of the finished product, thus insuring a minimum of scrap metal in the final processing operations.

Such forgings are furnished either cleaned, trimmed, pierced, sized or otherwise freed of excess material, and are ready for machining or further finishing or fabricating operations. They also may be furnished as the finished or machined forging completely processed, ready for use by itself, such as a nut or tee, or as an item for incorporation in an assembly, such as automobile hardware.

Grain structure is uniform and dense, eliminating the disadvantages of porosity and rough surface finish. Nonferrous forgings also have high tensile strengths—the great strength and nonporosity often permitting reduction in weight of parts previously produced by other processes. Fewer finishing operations are necessary, and the required machining may be performed with maximum speed, due to free-turning qualities of nonferrous alloys and the absence of grit and chilled areas. However, higher strength naturally sacrifices machinability.

Many nonferrous alloys are readily adaptable to the forging process and have been successfully used. Among them are forging brass, naval brass, nickel silver, muntz metal, leaded brasses, aluminum bronze, manganese bronze, silicon bronze and several aluminum alloys.

At present, nonferrous forgings are used extensively by manufacturers in many diversified fields, such as hardware, automotive, electrical, chemical, plumbing and welding. Brass forgings have an important part in acetylene burners, air compressors, blow torches, beer dispensing equipment, compressed gas valves and fittings, fire extinguishers, pressure gages, gas and water meters, oil burner equipment, turnbuckles and parking meters.

Nonferrous forgings can be provided in a great variety of finishes, including pickled, bright-dipped, satin, bright polished, lead dipped and plated with nickel, chromium, copper or other metals. (Carl H. Pihl. *Steel,* Vol. 118, June 17, 1946, pp. 130-132, 134.)

Aluminum Rotors for Electric Motors

Condensed from "Revue de l'Aluminium"

Although various problems were encountered in the substitution of aluminum for copper in the rotors of asynchronous motors, it was found that aluminum compares very favorably with other metallic conductors if used properly. For electrical purposes, 99.5% aluminum is normally applied. For equal electrical conductivity it will have a section 1.6 times as large as that of copper but the weight is only about half. Aluminum must be protected from galvanic corrosion if it is in contact with electronegative metals.

The problems posed by the joining of the conductors and their connection to the terminal board were the most difficult since the poorly conducting aluminum oxide film must be eliminated. The increase in the size of the rotor coil will decrease the power, but frequently this may be minimized by improved ventilation and better utilization of the slots. A major advantage of aluminum in the manufacture of rotor casings is the ease of production.

Cast rotors with casings are not new but are more economical and more robust than brazed or welded copper. An intimate contact between the bars and the sheets is ensured by the good filling out of the slots, while cooling is appreciably improved. These rotors may be cast in a cast iron or steel mold. This method is simple and gives good, uniform results with the proper technique.

For very small rotors, 99.5% aluminum has insufficient castability; therefore, 1 to 2% silicon is added, which reduces the conductivity slightly. The use of secondary metal may lead to defects in manufacture or service as well as to irregularities in conductivity.

The mold and sheets should be preheated to 750 to 840 F. Better filling of the mold results from the use of a mold placed on a table vibrating at 3000 or 1500 cycles per min. with a very weak amplitude.

Centrifugal casting has various advantages, such as good appearance of the product, uniformity, and excellent penetration even if the fluidity of the molten metal is not very good. The casting temperature can be decreased and a lower preheating temperature of 300 to 390 F may be used. This method is just as rapid as the first two, particularly with intermediate size rotors.

Die casting gives perfect filling of the mold, is very rapid, and requires no preheating. However, the installation is costly.

In welded rotors with deep slots, it is preferable to braze using a low melting point aluminum alloy with 10% silicon as this is more rapid than autogeneous welding. A special, corrosive flux is required which must be removed by thorough washing.

There are no fundamental differences in the use of aluminum wire for winding rotor coils from the standard practice with copper except that the aluminum wire is not as strong. The only real problem is joining the conductors. The safest method is by welding.

Electric welding with no flux is best but oxyacetylene or acetylene-air with a flux

is more practical. Aluminum may be joined to copper by welding at a low temperature but a very corrosive flux is required. The use of an intermediate connector of aluminum partly covered with copper is preferable. (J. Piget. *Revue de l'Aluminium*, Vol. 120, Mar. 1946, pp. 89-93.)

Design of Powder Metallurgy Parts

Condensed from
"Western Machinery and Steel World"

Powder metallurgy fabrication is useful within definable limits, and it involves a group of design principles that are peculiar to it and which must be applied, sometimes laboriously, to each product under consideration before the latter can be classed as suitable or unsuitable for this method of manufacture.

Powder metallurgy has been successful because it has provided one or more of the following: Structures or alloys not possible by other methods, built-in lubrication for moving parts, controlled density variations, more economical fabrication, shorter tooling time, higher production rates, surfaces of greater wear resistance, maintenance of closer tolerances, elimination of secondary operation and set-up, or the use of a less critical material. The designer wants to know under what circumstances and in many cases to what extent these improvements become available.

Powder metallurgy is able to provide certain structures or "alloys" that are not possible by methods involving melting. It is often a more economical fabricating method than others that could be used for a particular part.

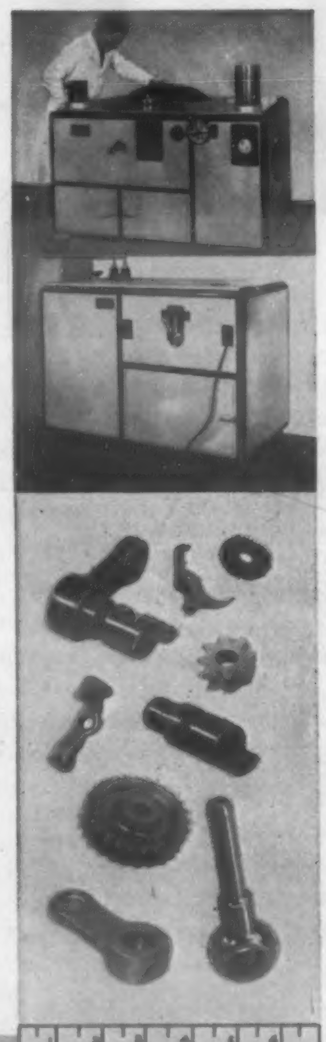
As compared with other processes, powder metallurgy involves relatively high raw-material cost. Tool costs for powder operations are among the highest. Production rates are highest with die casting and screw machine fabrications; they are high—occasionally very impressive indeed—with powder metallurgy. Tolerances are widest with sand casting. Powder metallurgy is the next closest, with tolerances of ± 0.0005 in.

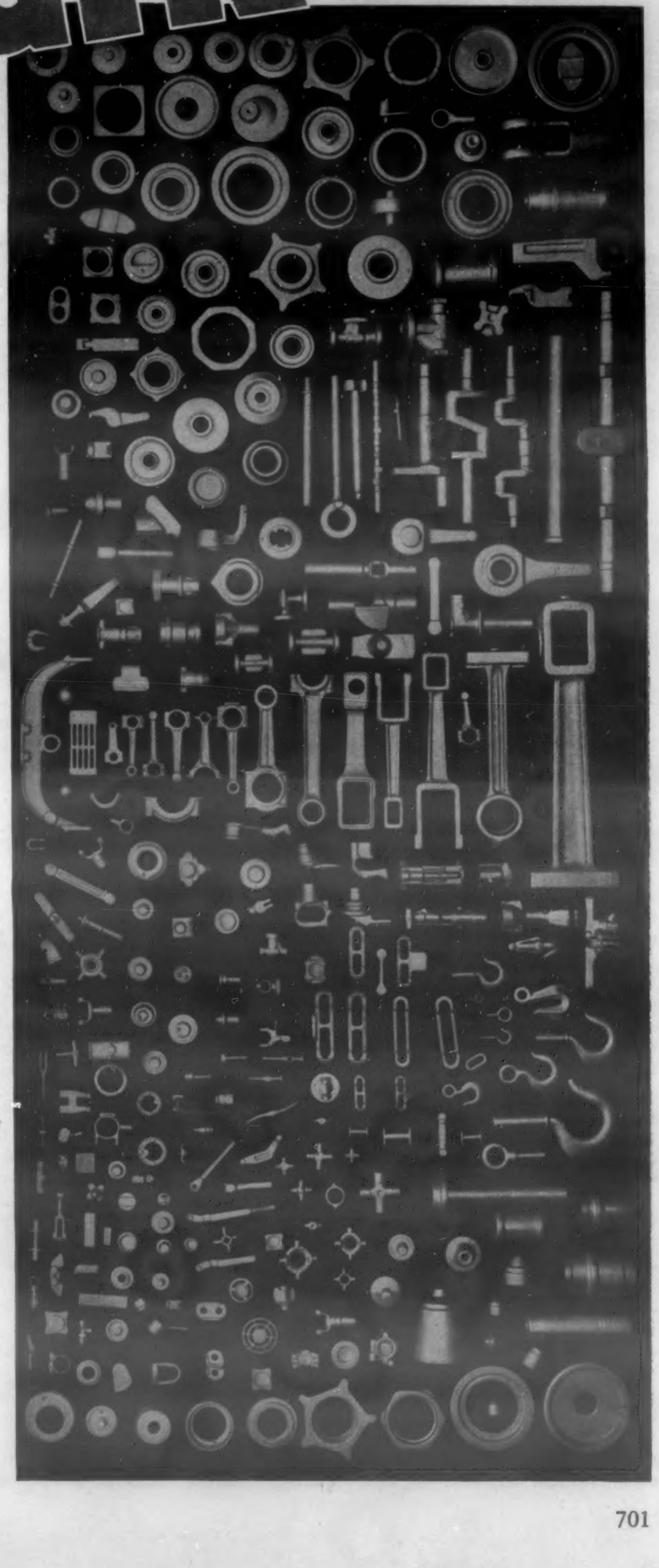
Powder metallurgy is primarily a process for large volumes. Most operations proceed at the rate of 200 to 1600 parts per hr., depending on the shape and size of the part. It is necessary to have minimum runs of from 500 to 50,000. The smaller the piece, the more volume is required to justify die costs and setting-up charges.

There is a certain amount of die wear caused by friction in ejecting the part from the die. A die averages about 50,000 pieces. Shapes that require a die of weak design should be avoided, for molding dies are subject to pressures up to 100,000 psi.

Avoid holes at right angles to the central hole or to the axis of pressing. It is important that all molded parts be made with edges beveled and that internal angles have fillets. Metal powders have almost no lateral flow in the mold.

Almost every level on the finished product requires its own separate die insert, which moves or floats in relation with other die parts. Sharp corners should be avoided at the junction of flange and the body. (M. T. Victor & C. A. Sorg. *Western Machinery & Steel World*, Vol. 37, May 1946, pp. 248-251.)





MELTING and CASTING

Melting, alloying, refining and casting methods, furnaces and machines. Iron and steel making, nonferrous metal production, foundry practice and equipment. Die casting, permanent mold casting, precision casting, etc. Refractories, control equipment and accessories for melting furnaces.

British Iron and Steel Economy

Condensed from "Metallurgia"

The president of the Iron and Steel Federation in May, 1945 asked all members of the British steel industry to submit a plan, to be carried out over five years, involving major improvements and new construction to put the industry on an efficient operating basis. The resulting report was issued as a White Paper.

A similar plan was launched in 1932, and considerable progress was made until the war interrupted it. The objects of the new plan are to make good the further modernization and development which would have taken place during the last six years had there been no war; to enlarge steel-making facilities to bring them into close relationship with the higher demand for steel products that may be anticipated; and to ensure the most effective use of plants by concentrating production into efficient units of appropriate size, with due regard to availability of raw materials and the distance to markets.

At the rate of progress achieved in five years before the war, the whole industry would have been renewed by 1950. Peak domestic steel consumption was 11,600,000 tons in 1937, and it is estimated that home consumption in 1950-55 will be 13,000,000 ingot tons per annum, and export demand should be 3,000,000 tons. Hence, an efficient capacity of 16,000,000 tons should be aimed at, with import provisions for 500,000 tons when demand is normal.

Scrap would form 55% of raw material, with import of not more than 250,000 tons. Hematite and basic pig iron requirements would be 8,500,000 tons, of which 7,500,000 tons would be imported ore and the balance home ore, excluding the tonnage for foundry pig iron. Blast furnace capacity should be increased from the present 7,500,000 tons to 9,000,000 tons.

Actually, 3,000,000 tons of present pig iron capacity and 4,000,000 tons of steel ingot capacity would be scrapped while new pig iron capacity of 4,750,000 tons and new steel capacity of 6,000,000 tons were being built. New building during the five-year period should proceed at 40% of the industry's capacity.

The main increase in ingot capacity would be based directly on home ores, the total increase in the Lincolnshire and Northamptonshire areas being 60%. Notable items of increase are: Five new continuous mills with an average capacity of 450,000 tons each; the erection of a broad flange beam mill on the North East Coast of 350,000 tons capacity and a new continuous strip mill in South Wales for sheets and tin plates, with a hot strip capacity of 1,000,000 tons a year.

Under the new plan there will be only five steel works, of which two would be devoted solely to plates, one to billets and light and medium sections rolled from billets, one to rolling heavy structural materials, and one to rails and special billets. Plants producing heavy rails would be reduced from eleven to four.

It is proposed that part of the rolling mill equipment be obtained from the United States at a cost of £9,000,000. The present position is very critical and unsatisfactory because the question of public ownership of the steel industry makes it essential that there should be discussion between the Government and the industry before the industry can determine how far it is practicable to proceed with the proposed plan. (*Metallurgia,* Vol. 34, May 1946, pp. 1-3.)

Control of Molding and Core Sand

Condensed from "Fonderie"

The control of mold sands may be limited, in the author's opinion, to frequent tests of the moisture content, green strength and grain size. The measurement of permeability seems to be less important. The moisture content is determined as the loss in weight after drying at 220 to 230 F. It is recommended that the sand be as dry as possible.

The determination of the green strength permits economy by avoiding excessive additions of new sand. The moisture content of the specimens must be controlled, as it has a great influence on the green strength. The fineness of the sand is determined by a method similar to the A.F.A. standard. The A.F.A. Grain Fineness Number is considered to be a useful index of the results.

Since the permeability increases with the size of the grains, the examination of the fineness gives an indication of the permeability of the sand while eliminating variations due to differences in moisture and clay content. Tests show that it is easy to decrease the permeability of the sand by small additions of fine sand but hard to increase the permeability since large additions of coarser sand are required.

The shape of the grains has no effect on the permeability unless the sand grains are very small. Clay modifies the permeability of the base sand, as increasing additions first absorb the fine grains with an increase in permeability, then the clay fills the interstices and decreases the permeability. Since permeability is often the answer to foundry defects, permeability measurements continue to be made but more importance is attached to the fineness tests which are made every day on each category of sand.

The tests recommended for core sands are a determination of the fineness of the siliceous sands as received and, most important, the measurement of the baked strength of specimens made under the same conditions as the actual cores. Where green strength is a factor, this property may be easily determined by tests similar to those used on mold sands.

The baked strength as measured by a transverse test is very useful in comparing the influence of various additions and methods of producing cores. At first the baked strength increases with the size of the grains, then passes through a maximum and decreases rapidly for large grain sizes. It decreases rapidly with increasing amounts of clay or dust.

Baked strength tests have also been used to determine the optimum foundry baking conditions. The maximum strength was found with a baking temperature of 465 F. (R. Guerin. *Fonderie,* Feb. 1946, pp. 43-52.)

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Carbon Products in Steel Plants

Condensed from "Iron and Steel Engineer"

The outstanding properties of carbon as a lining for blast furnaces are that it is not affected by the slag, no matter how corrosive; it is not attacked by molten iron; its shape is not affected by any temperature attained in blast furnace operation; and its strength at the furnace's highest temperature is equal to that at room temperature.

Various forms of carbon have been used for a number of years for lining European blast furnaces, but it is only recently that it is being used in American furnaces. It seems desirable to use blocks in the largest possible sizes that can be handled easily, thus reducing greatly the number of joints.

The blocks used in the wall are machined so that butting faces, made up with carbonaceous cement, are tightly joined. The joints between hearth blocks should be 1½—2 in. wide and filled with carbon paste, of the same material as in the blocks, tamped in hot.

Virtually all electric ferroalloy furnaces are lined with carbon because it is the only material that will adequately resist the corrosive slags at the high temperatures required.

Carbon bricks have been used for 20 years for lining pickling tanks, and at present virtually all stainless steel pickling is done in carbon-lined tanks. Carbon Raschig rings are used in scrubbing towers for removing carbon dioxide in connection with a bright-annealing process. Carbon tubes, beams, and blocks have been and are used in Cottrell precipitators for recovering phosphoric and sulphuric acids.

"Karbate" materials (impervious carbon and graphite) have high heat transfer properties and are used for several types of heat exchangers in the iron and steel, chemical and plating industries. They resist all but the most highly oxidizing chemicals, and are particularly useful in handling phosphoric, hydrochloric, hydrofluoric, and sulphuric acids and mixtures of nitric and hydrofluoric acids. Fittings, valves, pumps, condensers, and other complicated forms of equipment made from these materials are available.

Mold plugs of carbon may be used several times, if handled properly. Hot metal does not stick to carbon, danger of inclusions is eliminated, and there is no pick-up of carbon, even with low carbon heats.

Carbon cast in iron stools, or as the complete stool, has been tried in pouring ingots. Results indicate that graphite is more economical. Increased number of pours is obtained and stickers are eliminated.

Experiments have indicated that by properly placing a carbon rod in a blind riser, a number of advantages result. Graphite molds are used in casting of both ferrous and nonferrous metals, and for over-metal casting. A comparatively new use of carbon is for lining run-out troughs and runners of blast furnaces.

Many other uses of carbon and graphite of less general application have been developed. (Frank Vosburgh. *Iron & Steel Engr.*, Vol. 23, May 1946, pp. 60-67.)

FABRICATION and TREATMENT

Machining, forging, forming, heat treating and heating, welding and joining, cleaning and finishing of solid materials. Methods, equipment, auxiliaries and control instruments for processing metals and nonmetals and for product fabrication.

Heat Treatment of Aluminum

Condensed from "Light Metals"

Some years ago it was noticed that duralumin gradually becomes harder and stronger during storage. It has been found since that four of its elements—aluminum, copper, magnesium and silicon—have some effect on the heat treatability of the alloy. It is agreed that the improvement is due to the presence of some element which is more soluble in aluminum at high temperatures than at low.

If an aluminum alloy containing 4½% copper is cooled slowly from a liquid state it will begin to solidify at 1155 F and will become completely solid at 1065 F. When 970 F is reached, the $CuAl_2$ becomes precipitated. As the alloy cools further, the solubility of the $CuAl_2$ continues to decrease so that at ordinary temperatures only about ½% copper (as $CuAl_2$) remains in solution.

Suppose we now reheat this alloy. The copper-aluminum will start to dissolve again and finally reach a saturated solution. Theoretically, 5.4% copper is the point of complete saturation, though this is impossible to attain. In the foundry, then, we have obtained a saturated solid solution. If we quench as quickly as possible in cold water, the $CuAl_2$ will remain in solution and we shall obtain a supersaturated solution.

By heating at, say, 300 F the $CuAl_2$ is precipitated in fine particles until equilibrium is reached. Full precipitation could be reached more quickly by reheating, say, to 930 F and cooling slowly, but actually the structure obtained by the slower and less drastic method gives superior physical properties if the treatment is stopped before full equilibrium is attained. It is this kind of heat treatment which is used with aluminum alloys.

Magnesium silicide aids an aluminum alloy to be heat treated because of its higher solubility at high temperatures than at low. Accurate thermostatic control is necessary, the allowable range being 68 F. It is considered that the atoms in the supersaturated alloy lie in orderly rows and are evenly distributed through its mass.

It is easy to slide one layer against another and cause distortion, the metal thus having good ductility. When the precipitation of $CuAl_2$ starts, these molecules are deposited at random in a disorderly fashion, and, having a keying effect, prevent the relative movement of adjoining layers, making for decrease in ductility and increase in hardness.

Later the molecules of $CuAl_2$ coagulate and form fewer but larger particles. Hence, the metal becomes softer again and its physical properties begin to deteriorate. Thus, the temperature range and heating time are as important for the low temperature precipitation treatment as for the high temperature solution treatment—perhaps more important.

Some alloys are given good qualities by the high temperature treatment, being stronger than as cast and having good ductility. When maximum strength is required, the double heat treatment should be given.

The time taken to get the castings from the furnace to the quenching tank must be as short as possible to retain as much $CuAl_2$ or Mg_2 Si as possible in solution. (E. Carrington. *Light Metals,* Vol. 9, July 1946, pp. 336-342.)

Friction Sawing

Condensed from "Iron and Steel Engineer"

Friction sawing employs the heat of friction in a useful manner. The extremely high speed of the saw blade generates considerable heat at the point where the blade contacts the material being cut.

When the contact surface of the piece being cut reaches a temperature at which it is red hot, its tensile strength reduces very rapidly and continues to reduce as the surface gets hotter. The blade edge is relatively colder and relatively much stronger than the weakened contact surface. At a point above red heat, but below the melting point, the weakened surface can no longer resist the sliding action of the blade, and it is wiped away.

The removal of the initial surface exposes succeeding surfaces immediately below to the same action and the process continues until the section is severed, provided the blade and driving mechanism have sufficient capacity to continue the generation of heat at a rate faster than it can be absorbed by the maximum length of surface contact of the material.

The temperature required on the contact surface of steel to insure that removal takes place by friction sawing is necessarily at, or above a red heat, but considerably lower than the various melting temperatures of steels, and is probably between 1600 and 1800 F.

The power required to maintain uniform velocity increases directly with the pressure. The blade and driving mechanism must have sufficient capacity to maintain uniform velocity while sufficient pressure is being exerted to generate more heat than can be absorbed by the maximum length of surface contact to be encountered.

A smooth-rimmed blade will permit continuous production cutting of all high carbon steels (0.60 to 1.00% carbon). After many cuts the outside corners of the rim will lose their original sharpness and show a slight rounding. The amount of burr on the severed faces of the steel shows a slight increase. Redressing brings back the sharp corners of the rim.

By indenting the rim in a manner resembling gear teeth of about ¼-in. pitch, the blade readily severs any low carbon steels with less energy than that required by a smooth rim blade when cutting high carbon steels of the same section, area and shape. With proper cooling, the rim will not adhere to foreign metal, and the resultant small burr, and energy required, remain nearly constant through several hours of cutting.

The burr developed by 8 to 10 hours' cutting may require redressing of the blade. Redressing may be accomplished by the same hobbing operation used for forming the teeth in the original blade.

The efficiency of friction sawing increases with rim velocity for speeds up to 20,000 ft. per min., but remains nearly constant for higher values. The steel used in friction saw blades permits the development of sufficient tension to allow long service and several redressings.

Two other types of blade are: tube saws and hot saws, both of which permit a substantial reduction in the per cut of tooth

surface.

The rate of feed varies directly with the blade pressure, which is greater than the horizontal pressure against the blade center and increasing as the angle of contact increases below the horizontal.

For irregular shapes, such as I-beams or channels, the motor load varies directly with the change of pressure angle as the blade progresses through the section, and is greatest at the finish of the cut. The blade will stand a higher pressure and motor load where the length of contact is shorter than the maximum safe limit.

The efficiency of cutting, for a given width and condition of blade, is greater where the length of contact is shorter and the rate of feed faster. The efficiency decreases as the corners of the blade become rounded to a larger radius, because this rounding increases the surface area on which heat is being generated. (James M. Lewis. *Iron & Steel Engr.*, Vol. 23, June 1946, pp. 81-90.)

Degreaser Maintenance

Condensed from "Industrial Finishing"

Maximum operating economy with a degreaser calls for the removal of all avoidable solvent losses. Important factors to be watched and correct procedures to be employed under usual operating conditions are: draft elimination, heat balance, air mixing of solvent caused by spraying solvent through air; pump and valve maintenance, solvent carry-out, excessive solvent vapor displacement; speed of work through solvent vapor zone, heating work to vapor temperature, moisture in solvent, distillation of dirty solvent, draining of filters, and conveyor maintenance.

Every degreaser should be located so that it will not get cross drafts from ventilating fans, open windows or open doors; yet it should be housed in a well-ventilated room—one of 20,000-cu. ft. or larger. The vapor level in a degreaser should be kept constant, and heat input must be sufficient so that when the cold work enters the degreaser, the vapor line will not drop below the bottom of condenser.

To prevent excessive loss when spraying the solvent through the atmosphere, observe the following: (1) the spray nozzle should be underneath the true vapor line when spraying and draining; (2) heat input must be sufficient to keep true vapor level above top bank of sprays; and (3) direct jets so that ricochet is within the vapor zone.

Recommended speed for an average work load entering and leaving solvent vapor zone is 11 ft. per min., and allowance must be made for parts whose surface contour will cause excessive displacement of vapor. Parts should remain in the machine until heated to the temperature of the solvent vapors, and precautions should be taken to see that the work is put in dry.

Presence of water in a machine is indicated by cloudy vapors, and any water that accumulates on the surface of solvent should be removed before operations begin. (S. J. Trezac. *Ind. Finishing*, Vol. 22, June 1946, pp. 44, 46, 48, 50, 52, 54, 56.)

"Dry" Galvanizing

Condensed from "Metal Industry"

The purpose of the flux in hot galvanizing is to clean the surface of the object to be galvanized and also the surface of the molten zinc immediately before they come in contact with each other. In the "wet" method, the flux is applied on the surface of the molten zinc; in the "dry" process, the flux is applied on the surface of the work-piece. The essential difference between these two methods, however, is that in the "Wet Process" a zinc bath with no more than 0.02% aluminum is used, while in the "dry" process the bath is alloyed with 0.2 to 0.3% aluminum.

As a rule, a solution of 40 to 50% zinc chloride is used as a flux in the "dry" process. The objects are immersed in this solution; then they are placed in a drying furnace and heated until most of the water evaporates, leaving a layer of zinc chloride on the surface.

In the "dry" process, it is important to wash the surface of the work-pieces after pickling as carefully as possible, to dry the objects as completely as possible, and to use no more flux than is necessary. In hot galvanizing, aluminum is used as an alloying metal in two ways: first to brighten the zinc coating, and second, to alter the structure of the coating. For the first purpose an aluminum content of 0.02% will suffice; for the second, the aluminum content of the zinc bath must be 0.2 to 0.3%.

The main range of application for the "dry" process is the hot galvanizing of flat sheets, since the zinc coatings so formed have excellent bending qualities. In "dry" galvanizing there are no alloy layers, and the coating is only about half as thick as in "wet" galvanizing. The high cost due to the hand labor needed for a small output is the one disadvantage of this process. (H. Bablik. *Metal Industry*, Vol. 68, June 21, 1946, pp. 487-489.)

Soft Soldering

Condensed from "The Welding Journal"

Soft soldering is the process of joining metals without melting the base metal using an alloy, or solder, fusible at temperatures below 700 F. In hard soldering, or silver soldering or silver brazing, the solder fuses at temperatures above 1200 F.

The use of 60% tin-40% lead, or 50-50 solder makes it possible for even the novice to do acceptable soft soldering. The high tin content of these solders makes them easy to work with. In the case of a tin content of 30%, experts encounter difficulties.

For soft soldering nonferrous alloys, one can use an oxyacetylene welding blowpipe or an air-acetylene torch with single hose connection. Tip sizes for soldering vary from Nos. 6 to 15. Oxygen is used in combination with city gas or with natural gas, the oxyacetylene flame being too hot for soft soldering. A second type uses acetylene and atmospheric air, this being favored by electricians, plumbers and sheet metal workers because of small portable cylinders of acetylene used.

At one temperature the solder begins to melt; at another it begins to flow, the latter being important because the metal must be heated to a temperature higher than the flowing temperature, or the solder will not flow. A few solders melt and flow at the same temperature, these being "eutectic" solders, being suitable for bead joints but not lap joints. The plastic range is that between melting point and solidified point upon cooling.

The following are temperature characteristics of commonly used solders, valuable to know when changing from one solder to another:

Composition	Melting Point F	Flowing Point F	Plastic Range F
Tin-Lead, 60-40	361	372	11
Tin-Lead, 50-50	361	421	60
Tin-Lead, 40-60	361	453	92
Tin-Lead, 30-70	361	486	125
Lead-Silver, 95-5	579	689	110
Lead-Silver, 97.5-2.5	579	579	(eutectic) 0
Tin-Lead,-Antimony, 28-70-2	361	484	123

Fluxes are important as they shield the cleaned metal from the air, thus retarding formation of an oxide film, and they remove any oxide that might be on the surface when the solder is applied. Fluxes can be obtained in powder, paste or liquid form, or as cores in the hollow wire form of solder. Some flux makers add wetting agents to make the flux thin out and cover a larger area.

The lower the tin content, the more care must be taken. Thus, all dirt and grease must be removed from the surface before fluxing. Surfaces must be made to fit and contact each other closely.

One should heat the metal above the flowing temperature and heat the lapped joint until the solder drops disappear from the bevel. One should dip the solder in the flux from time to time. Do not disturb the joint until the solder has solidified. Use water to clean off traces of the flux which are corrosive.

With the first type of blowpipe, with an oxy-city gas flame, the correct flame is soft; when the second type is used with the air-acetylene flame, the flame should show a bright, sharply-defined inner cone and a pale blue outer flame. (G. H. Bohn. *Welding J.*, Vol. 25, June 1946, pp. 513-516.)

Welding Aluminum

Condensed from "The Iron Age"

Though sometimes considered a difficult material to weld, aluminum is, in fact, one of the most readily weldable of all metals. Pure aluminum melts at 1218 F, while aluminum alloys melt at even lower temperatures. The melting point of steel is around 2700 F.

One of the most critical factors in the welding of aluminum is oxidation. On all

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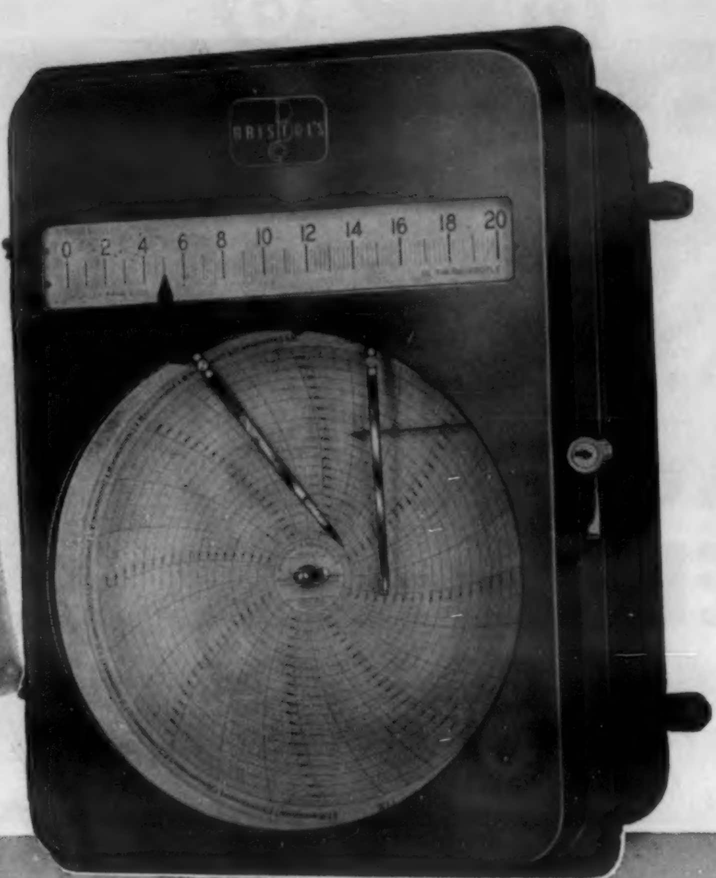

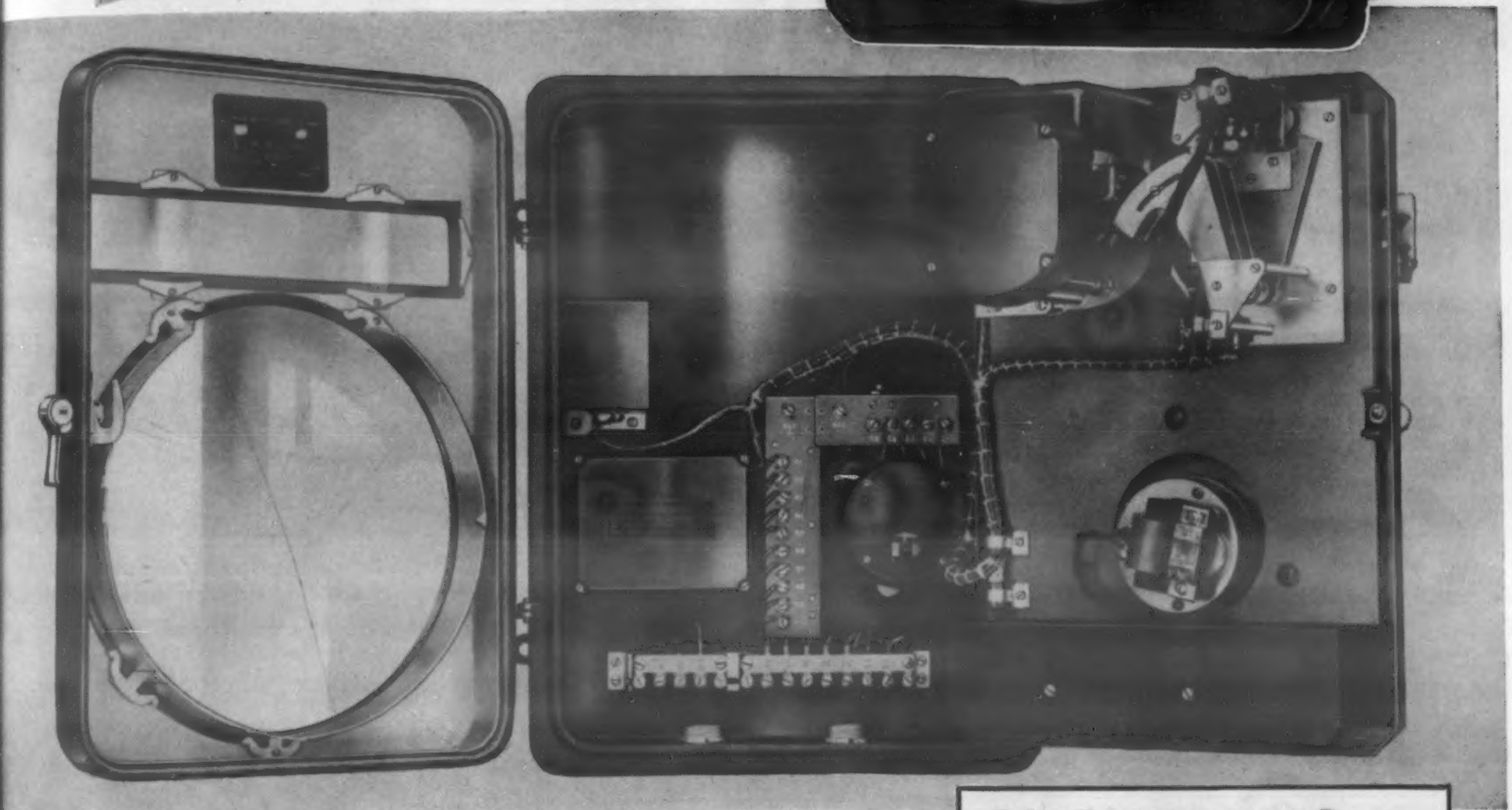

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exposed surfaces, aluminum oxides readily form a film or coating. Its removal is complicated by the fact that it has a higher melting point than the base metal.

In the various forms of fusion welding this difficulty is overcome by the use of fluxes. The flux combines chemically with the oxide to form a fusible slag which may be removed readily from the weld puddle, as it rises to the surface during welding.

Another critical factor is the apparent weakness of aluminum alloys at high temperatures. Many aluminum alloys are partially molten over wide ranges of temperature. When temperatures at which partial melting occurs are reached in welding, the aluminum alloys show a tendency to collapse. Because the temperatures used in welding aluminum are not within the visible light range, showing no changes of color, it is difficult to determine when melting temperatures are approached in any part of a piece of metal being welded.

The heat treatable alloys of aluminum are in general not as suitable for welding as the non-heat treatable alloys. These alloys, however, if heat treated subsequent to welding, develop higher strengths, but if welded after heat treatment much of the strength will be lost.

The earliest welding process to be successfully employed on aluminum, and still one of the most popular, is that method of fusion welding which makes use of the torch flame. Gas welding is normally confined to materials 1/32-in. thick or over. For thinner materials, spot or seam welding is employed.

Many of the gas welding processes may be used to weld aluminum alloys in their various forms, such as sheets or plates. Alloys suited for general torch welding purposes are 2S, 3S, 52S, R353 and R361.

The thickness of the material will largely determine the method of edge preparation. On thin material up to about 1/16 in. no particular edge preparation is needed. Material of this thickness can usually be welded with a plain butt type of weld.

It is desirable to preheat when welding aluminum plates ¼-in. thick or over in order to prevent cracks, assure more complete penetration and reduce gas consumption. Preheating to a temperature of 500 to 700 F is sufficient.

With the oxyhydrogen flame sufficient heat is produced to weld aluminum up to ⅜-in. thick. For practical purposes, however, many users are inclined to reserve oxyhydrogen welding for the thinner sheets and use oxyacetylene welding for thicker materials, say from 3/16 in. up. In welding aluminum, a neutral or slightly reducing flame gives the best speed and economy as well as a clean weld of good soundness.

The type of welding rod to be used will vary. The 5% silicon welding rod is recommended for most alloys, inasmuch as this rod possesses higher strength and good corrosion resistant properties.

To insure the proper distribution of flux, it should be painted on the surface to be welded and also applied to the welding rod. Aluminum flux is generally obtained in the powder form. It is best prepared by mixing the powder with water to form a thin, freely flowing paste. After the pieces to be welded have been properly prepared and fluxed, the flame is passed in ever

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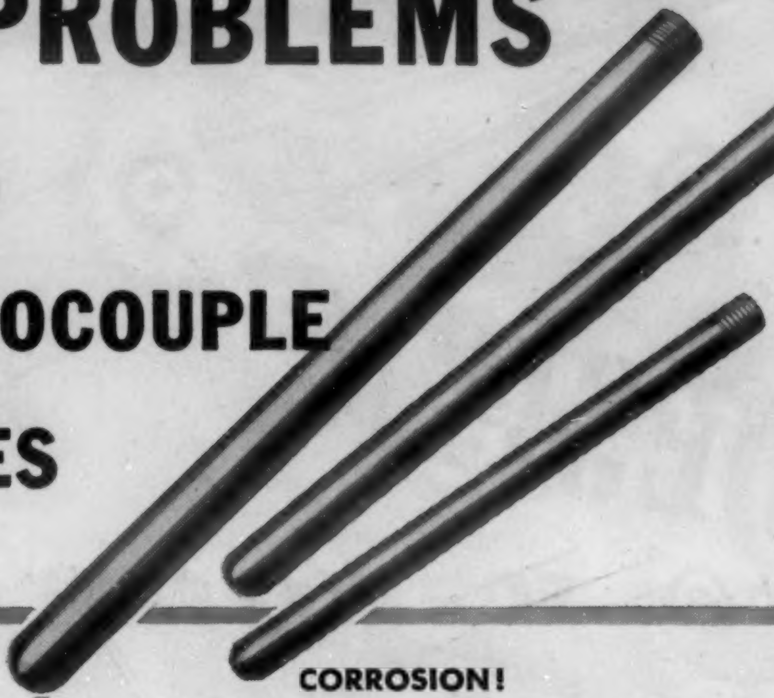

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smaller circles over the starting point until the flux melts or the rod begins to adhere to the surface.

After the flux melts, the base metal must be melted before the rod is applied, or else the metal and the filler metal may be brought to the molten state simultaneously. To prevent oxidation, it is quite essential to keep the welding rod in the weld puddle at all times. (*Iron Age*, Vol. 157, June 20, 1946, pp. 50-55.)

A French High Frequency Furnace

Condensed from "Fonderie"

The three main types of electric melting furnaces are resistance, arc and induction. Resistance furnaces are very simple, but high temperatures cannot be obtained. Arc furnaces contaminate the charge with carbon from the electrodes and volatile elements may be lost from the melt. Induction furnaces may be constructed with or without a magnetic core.

The latter operate with a current that may be generated by an a.c. generator, which has relatively low, fixed frequency; a spark gap generator, which generally has very low output; or by an electronic tube, as the present furnace, where a triode tube functions as the source of the alternating current.

Electronic tube induction furnaces have many advantages for small charges, especially of expensive metals. The frequency may be as high as several million cycles per sec. and is easily regulated. An adjustment of the circuit when the charge melts is not essential as it is with furnaces using an a.c. generator. Melting is very rapid. The operation of these furnaces is flexible and uniform. The crucible is deep to minimize oxidation. Moreover, the melting can be conducted in vacuum or under a controlled atmosphere if desired.

Since the heat is generated in the metal, there is no danger of carburizing the melt nor is there any silicon pick-up from the silica crucible. Melting losses are insignificant; therefore, turnings may be remelted economically. The equipment is easy to maintain as there are no moving parts. The crucibles are cheap and have a long life. However, the equipment is more expensive than an a.c. generator and is justified only for small charges.

Full details are given of a 2-crucible, 250-kw. installation which has been in operation for almost two years in Paris. This furnace is one of the most powerful electronic tube types that has been built. Particular attention is given to the simplicity of operation and to the safety provisions. The nominal capacity is 110 lb., but actually 287 lb. may be melted.

The average melting times are 21 min. for 192 lb. of steel and 32 min. for 287 lb. However, some heats are much shorter. Each pound of steel melted requires 0.57 kwh. With 176-lb. heats of steel, each crucible will last about 100 heats. The same type of construction has been used for 100, 40 and 20 kw. furnaces. (A. de Saint-Andrieu. *Fonderie*, Apr. 1946, pp. 143-155.)

A New Welding Technique

Condensed from "The Welding Engineer"

A new flame process has been invented for welding, brazing and hard-facing with powdered metals by R. A. Wiese, head of Powder Weld, Inc., Brooklyn, N. Y. The metal or alloy is mixed with its flux in a carefully predetermined portion and fed to the work through a flame generated and controlled by a pre-selected combination of oxygen with fuel and processing gases.

Theoretically, the variety of materials which may be used in powder welding is limited only by the availability of the metal in powdered form and its stability in flame. This leaves the field wide open for copper, iron, aluminum, magnesium, manganese, nickel, lead, tin, zinc, cadmium and silver, and for the alloys of these metals plus alloys containing beryllium, bismuth, boron, carbon, chromium, cobalt, molybdenum and tungsten.

The equipment consists of a torch, control box with air and gas pressure regulating valves and a canister from which powdered metals are fed. The torch differs greatly from either a welding or cutting torch. Three control knobs project from the handle, being part of the 16 independent controls.

The process ordinarily makes use of three gases: Oxygen, a fuel gas and a cooling or processing gas. The fuel gas may be acetylene, hydrogen, butane, propane or any commercial natural or manufactured gas. The processing may be nitrogen, helium, argon or other inert gas.

A skilled operator can achieve exact control of the amount of flux, accurate control of the amount of mixture used per min. or per in. of weld or braze, control of the flame temperature and atmosphere, control of the temperature of the projected metal, and control of the temperature of the target or work surface.

The outfit can weld or braze like any other torch and, in addition, can use controlled atmosphere at the point of deposit. It can also be used without the processing gas as a conventional welding or brazing torch, its performance being excellent.

The method can also be used by the plastics industry to apply such chemical compositions as polythene, some polyvinyls, some silicones and some elastomers. Glass forming compositions such as silica and other frits resulting in enamels and glazed coatings can be applied in the same manner.

In the metal field it is admirable for hard facing, applying hard-to-handle alloys in any desired thickness. With this equipment a Detroit company bonds sprayed metal particles onto a prepared surface and subsequently fuses the deposited particles to one another and to the base metal to produce a dense, wear-and-corrosion resistant surface. A special nickel-chromium-boron alloy with a hardness of 56-62 Rockwell C is used. The bonding of sprayed particles is done at 1850 to 2050 F.

To apply an overlay, the surface is first undercut, then grit blast with medium steel grit. Flame spraying with the nickel-chromium-boron rod follows, the rod having as binder a plastic which soon burns off and leaves no harmful trace. (Clyde B. Clason. *Welding Engr.*, Vol. 31, June 1946, pp. 46-48.)

TESTING and INSPECTION

Testing methods and equipment for physical and mechanical properties, surface behavior and special characteristics. Radiographic, spectrographic, identification, metallographic, dimensional and surface inspection. Stress analysis and balancing. Specifications, standards, quality control.

Nondestructive Inspection of Castings

Condensed from "American Foundryman"

In general, nondestructive testing includes any method of inspection which will disclose the presence of defects in a part without destroying the part itself. When applied to castings, the definition may be extended to cover those methods which, while they may remove part of the casting, leave the final part still usable. There are a number of nondestructive inspection methods in regular use in foundries.

Visual examination consists of examining the surface of the casting with the unaided eye, the use of a hand lens or, in certain cases, low-power microscopes. This method is used to detect surface defects. Among the types of defects which are found by visual inspection are "burned-in" sand, blows, rat tails, cold shuts, swells, surface porosity and surface cracks.

Sound or percussion tests are performed by striking the casting with a hammer, thus producing a characteristic tone which will be changed by the presence of discontinuities. This method is generally not very satisfactory. It can only be used to detect very large defects and even then is not always a dependable test.

Impact tests involve impacting the casting in one of several ways to determine whether or not the piece will fail. The casting may be impacted by striking it with a hammer, dropping it from a specified height onto a solid plate, or by dropping a specified weight from a given height on the casting. Impact tests should not be trusted as acceptance tests for castings.

Pressure tests are used to locate leaks and to test the over-all strength of castings. Hydrostatic testing consists of filling the part with water under a specified pressure and examining the casting for leaks. The hydrostatic test shows over-all strength and the presence of leaks only at the time the test is made, and gives no real assurance that the part will continue free from defects in service. In service the casting may be subjected to stress variations which may cause filamentary shrinkage cracks to extend, thus causing leakage.

Steam and air may be used in pressure tests. However, steam should not be applied until the part has been hydrostatically tested. Air is particularly useful in testing small valves and fittings.

Radiographic examination using X-rays and gamma-rays is another widely used nondestructive test in foundries. If a metal plate, for example, is exposed to X- or gamma-rays, some will be absorbed by the plate; others will pass through. Defects inside the plate will absorb the rays to a lesser extent than the adjacent areas of the plate. Since the rays affect photographic emulsions in much the same way as light, a record of the defects present can be obtained.

The wave length of X-rays is inversely proportional to the applied voltage used in making the X-rays. Sensitivity, or the ability to register small defects, increases with an increase in wave length. However, the penetration of the X-rays decreases with an increase in wave length. X-ray equipment rated at 220 kvp. is suitable for up to 3 in. of steel. Rays from one million-volt equipment can be used up to 6 in. of steel.

Radiography using radium depends upon the emission of penetrating rays given off by radium. Gamma-rays have very short wave lengths and high penetrating power. This method is useful where the production of a foundry is not sufficient to warrant high voltage X-ray equipment. Since it is portable, the method is useful for jobs not accessible to X-ray methods.

Magnetic inspection can often be used to reveal shallow, fine defects not possible to detect with radiography. To use magnetic inspection, the part being tested must be capable of being magnetized. In general, the test consists of applying magnetic particles to the surface of the magnetized casting. If defects are present, the particles will form a line around the defects.

Magnetic inspection is often limited to certain critical locations of castings. A variation of the magnetic test is in the use of magnetic particles covered with material which fluoresces under ultraviolet light.

In electrical conductivity tests an electric current is passed through the piece using a constant voltage and observing any change in the amount of current to pass through as an indication of defects. It is practicable only where a large number of castings of the same design are made to close tolerances.

Penetrant tests utilize a highly penetrating oil in which is dissolved a substance fluorescent under ultraviolet light. A powder is dusted on the surface; it absorbs oil where defects are located and indicates the defect under ultraviolet light.

Supersonic testing methods have only recently been developed. In one method sound waves are set up at one end of the object, travel through the object and are reflected back either by the opposite end or by a flaw. The time of travel is measured. Thus, a flaw will be indicated by a shorter round trip time than that of a wave being reflected from the end. (C. L. Frear & R. E. Lyons. *Am. Foundryman*, Vol. 9, Apr. 1946, pp. 120-133.)

Standard Nonferrous Test-Bars

Condensed from "Foundry Trade Journal"

An investigation was carried out with the following designs of separately cast test-bars: Keel bar, a modified form of wedge bar designed by J. Stone & Co.; Institute of British Foundrymen bar, as modified by J. Stone & Co.; Eash-type bar, as used in the United States; and British Non-Ferrous Metals' Research Assn. bar. With the exception of the Keel bar, all of the patterns were cast in both the shaped and parallel forms in green-sand molds by 12 British foundries.

Alloys used were (A) aluminum bronze, (B) manganese brass, (C) phosphor bronze, (D) 88-10-2 gunmetal, and (E) 85-5-5-5 gunmetal. The pouring temperatures used were 2192 F for A, 1868 F for B, 2048 F for C, 2138 F for D, and 2084 F for E. The green sand used had a moisture content of 5.5 to 6.5%; A.F.A. green compressive strength of 6.0 to 8.5 psi.; and A.F.A. green permeability of No. 20-50. All the test-pieces were machined to 0.564 in. dia. and their mechanical properties plotted graphically.

As a result of these tests, it has been recommended to the British Standards Institution that the Keel bar should be tentatively adopted as a standard for copper-base alloy castings. The bar should be made round instead of having a square section. This will facilitate machining operations and provide a more rapid rate of cooling.

The bar has a diameter of 1 in. Its length may be varied to suit the testing-machine but shall not normally be less than 6 in.

The wedge-shaped riser tapers from a width of 2 in. at the top to ½ in. at the bottom; its depth is 4 in. Its length at the bottom is the same as that of the bar and at the top it is ⅛-in. longer.

For aluminum bronze and manganese brass, the test bar should be run from the bottom by means of a small ingate attached to one end of the bar. For other alloys, direct pouring into the feeding head should be satisfactory.

In odd cases, some initial difficulty may be experienced in meeting existing specifi-

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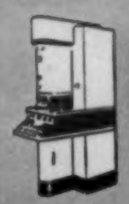
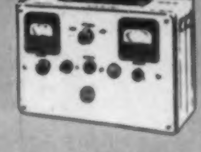
RCA ELECTRONIC EQUIPMENT FOR INDUSTRY



"Universal" electron microscope: adjustable magnification to 20,000 X

Vacuum Unit for metal shadowing, coating, and evaporation



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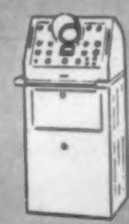
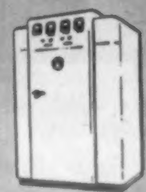
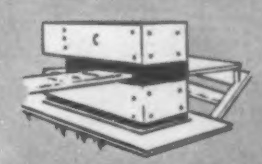


Test and measuring equipment



Electronic power generators for dielectric and induction heating



Electronic metal detector to protect machines and product quality

Very high-speed electronic time-interval counters

SCIENTIFIC INSTRUMENTS

RADIO CORPORATION of AMERICA

ENGINEERING PRODUCTS DEPARTMENT, CAMDEN, N.J.

In Canada: RCA VICTOR Company Limited, Montreal

cation requirements for gunmetal and phosphor bronze, when using the Keel bar. For the time being, the I.B.F. shaped bar might be allowed as an alternative for these alloys. There is every reason to believe that the form of Keel bar recommended will ultimately prove satisfactory for all copper-base alloys.

At one time the B.N.F.M.R.A. design of bar looked particularly promising. However, some trouble was experienced with entrapped oxide and dross inclusions in the test-pieces. Further study will have to be given to running methods if consistent results are to be obtained. (Frank Hudson, *Foundry Trade J.*, Vol. 79, June 20, 1946, pp. 185-191.)

Testing Plastics

Condensed from "Plastics"

Due to the numerous factors that enter into the manufacture and use of finished plastics goods, the only way to determine the suitability of a manufactured product is to test it under conditions as closely as possible simulating those it will encounter in actual use. Standard tests have their value as a guide only for a comparison of the properties of the various plastics.

Molded pieces of the melamines are found to be more practical than the ureas because they are more water resistant, much harder, and more resistant to staining. In commercial applications the expressed data sheet figure cannot be used, for besides the technique in molding and the difference in shape, the presence of inserts or machine scratches will change the results unfavorably.

Either of the standard Izod or Charpy methods for testing impact strength are based on single blow determinations; therefore, other tests were devised to indicate the effect of repeated impact at lower than ultimate breaking strength. Immersion in boiling water seemed to be the best test of heat resistance, the shape and thickness of the article being important factors. Alternately dry and humid conditions, temperature and rate of drying are also determinant.

X-ray analysis, either fluoroscopically or by means of X-ray film, is of immense value as a testing tool without destroying the piece. In design, differences of thickness, contour, and orientation of the fibers with respect to section may alter the physical properties.

Transfer molding makes for a more uniform dense material than compression molding. The final physical properties of phenolics are generally not as affected by over-curing by high temperature as are the ureas and melamines.

Usually impregnation of fibers by molecules of plastics decreases the strength but increases the water resistance. In the coating process the physical properties are better, but water resistance is not as good.

Insufficient pressure in molding can cause porosity, and excessive pressure can break down the fibrous structure. Temperature and humidity at the time of testing the piece, with the history of the molded article, can affect the dielectric strength. (H. R. Sjostedt. *Plastics*, Vol. 4, June 1946, pp. 58, 60, 100, 101.)

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BOOK REVIEWS

Magnesium

MAGNESIUM. *By L. M. Pidgeon, J. C. Mathes, N. E. Woldman, J. V. Winkler & W. S. Loose. Published by the American Society for Metals, Cleveland, Ohio, 1946. Cloth, 6 x 9 in., 265 pages. Price $3.50.*

This new book covers the extraction processes and production of magnesium as well as its working and fabricating. The five sections of this book are entitled:

- Magnesium—Extractive Metallurgy
- Magnesium Structural Design
- Magnesium Castings
- A Survey of Wrought Magnesium Alloy Fabrication
- Corrosion and Protection of Magnesium

Each of these sections is a reprint of one of the five popular lectures on magnesium that were presented during the twenty-seventh National Metal Congress in February, 1946. As these lectures were concise yet thorough, this volume covers the field of magnesium and its alloys in a practical and valuable manner.

The first, third and last sections include bibliographies. Well chosen illustrations and diagrams appear throughout and add value and interest to the book.

Numerous tabulations of design data and engineering information on the important alloys of magnesium are presented, and it seems unfortunate that many of these items are listed by the producers' designation of the alloy rather than by a standard specification number. There are, of course, several reasons for this and it is hoped that our engineering philosophy will tend to emphasize standard specifications and their increased use both in the manufacture of engineering materials and in reporting test data and characteristics.

—R. S. BURPO, JR.

American Arc Welding Patents

AMERICAN ARC WELDING PATENTS. *Edited by W. H. Simon. Published by Modern Technical Book Co., 55 W. 42 St., New York, N. Y., 1945. Cloth, 9 x 11¼ in., 574 pages. Price $40.00.*

This monumental work is divided into three sections—72 pages which index by subject the patent numbers and inventors or assignees for patents on electrodes, welding rods and alloys, fluxes, holders, shields, etc.; a second section indexing the patents according to inventors and assignees; and the third section (about 450 pages) giving brief abstracts of patents in numerical order with patent illustrations, filing date, duration and names of inventors and assignees. The period covered is Jan. 1, 1900 to July 1, 1945, but there is included a brief survey of patents issued before Jan. 1, 1900.

An index of American welding pate[nts] is in effect an index of world patents [in] this field because of the leading role [of] the American welding industry. This b[ook] should be of inestimable value to e[ngi]neers, designers and research workers [as] well as patent attorneys working in [the] welding field.

This volume is the first of a se[ries] which Dr. Simon plans to publish over [the] years. The succeeding sections will co[ver] equipment and machines and applicatio[ns].

—FRED P. PETE[RS]

Elements of Ammunition

ELEMENTS OF AMMUNITION. *By Th[eo]dore C. Hart. Published by John Wi[ley] & Sons, Inc., New York, 1946. Fabriko[id,] 6¼ x 9¼ in., 412 pages. Price $6.0[0].*

There is all too little available in bo[ok] form on the technical aspects of ordna[nce] equipment. When war suddenly beca[me] imminent, around 1940, everything r[e]quired for the modern army had to b[e] produced practically from scratch by pe[o]ple with no previous knowledge of th[e] weapons of war. And what a "rat rac[e"] it was! Shops in the jewelry manufactu[r]ing business started making bomb fuze[s] and air conditioning equipment produce[rs] found themselves in the armor pierci[ng] shot business. Everywhere these peop[le] with war contracts in their hands haunte[d] the book publishers and searched throug[h] libraries for books to get some fund[a]mental information about the new prod[]uct which they were now making. Gen[]erally, they ended up with nothing bette[r] than Hayes' "Elements of Ordnance" which, for example, devotes two skimp[y] chapters to ammunition. So, these or[d]nance novices had to learn the hard wa[y] by trial and error and, consequently, mad[e] mistakes which otherwise might have bee[n] averted if a fund of basic ordnance liter[]ature would have been available.

"Elements of Ammunition" is an a[t]tempt to fulfill the need for a funda[]mental book on the complex and inte[r]esting field of ammunition. The boo[k] has succeeded in accomplishing this pur[]pose. It is written for the future begin[]ner in ammunition design and develop[]ment work. It is not for the advance[d] and experienced ammunition man. H[e] must go further for additional educatio[n] to the many technical reports and paper[s] which were written during the war.

The book deals with the propertie[s,] description and characteristics of thre[e] varieties of ammunition: the conventiona[l] older types in existence during Worl[d] War I, of which small arms and artiller[y] ammunition are examples; the types de[]veloped between World War I and II such as aircraft ammunition, improve[d] types of small arms, artillery and pyro

nics ammunition; and the types developed primarily during World War II, h as rocket ammunition, and the many v varieties of all types of ammunition. ere is an excellent final chapter on all-important subject of ammunition king.

This book will not only serve as a ic and invaluable tool for the ordnance ineer, but also should prove to be a venient and a definitive source of ormation for all military and civilian sonnel interested in the subject of munition.

—H. R. CLAUSER

Rays

RAYS IN PRACTICE. *By Wayne T. roull. Published by McGraw-Hill Book ., Inc., New York, 1946. Cloth, 6 x 9 , 615 pages. Price $6.00.*

Not since Clark's "Applied X-Rays" s a book of this caliber appeared on the bject of X-rays. It is comprehensive d complete: it covers in considerable ail the whole range of X-ray knowlge from the nature and properties of rays to their many and varied applitions. It is also an up-to-date book for includes discussion on the most recent dings and developments in the field i.e., supervoltage X-ray equipment, new plications of radiography, and modern antum mechanics).

The first half of the book deals with:) the history of X-rays, (2) the fundaentals of X-ray tubes, (3) the X-ray ectrum, (4) the generation absorption, attering and diffraction of X-rays, and) X-ray detection measurement, and gistration. The second half takes up e applications of X-rays. This includes chapter on the use of X-rays in the edical field, two chapters on industrial diography, and finally, a very thorough d lengthy treatment of X-ray diffraction.

Although complete and technically und, the book, like so many technical oks, makes for difficult reading; it follows conventional methods of text-book esentation with its dense typography, its inimum of sub-heads, and its lifeless e drawings.

—H. R. CLAUSER

ubber as an Engineering Material

UBBER IN ENGINEERING. *Published by hemical Publishing Co., Inc., Brooklyn, . Y., 1946. Cloth, 5¾ x 8¾ in., 267 ges. Price $5.50.*

This book was prepared in England nder the joint direction of the Controller f Chemical Research of the Ministry of upply and the Directors of Scientific Rearch of the Ministry of Aircraft Production and of the Admiralty. The actual esearch activities upon which this book based were carried out at the laboraries of the Imperial Chemical Industries, Ltd.

The purpose of this volume is to furish engineers with a general survey of e fundamental properties of rubber. It as been written in a manner calculated o make it of interest to a wide variety of readers who might be interested in rubber engineering material.

Contrary to the usual practice, an author index followed by a subject index are placed just ahead of page 1. Excluding the introduction, this volume is made up of four parts. Part 1, the Rubber-Like State, establishes the background for Part II, The General Properties of Rubber. Part III is a short section entitled Rubber Technology, comprising a general outline of the more important processes used in making rubber articles, some additional notes on the physical properties of synthetic and natural rubbers, and a few remarks about the bonding and molding of rubber compounds. Principles of the Design of Rubber Engineering Components is the last section of the book except for the Appendices, which give some of the theoretical bases for the action and characteristics of rubbers.

This book has been printed by the "photo-offset" process and is a remarkably clear job; the only drawback to this process is that the half-tones are not very clear. Line drawings and graphs are liberally used, and references are listed at the end of each chapter.

For both materials and design engineers, on one hand, and technical students, on the other, this survey of the engineering properties of rubber will be of help and interest.

—ROBERT S. BURPO, JR.

ASTM Proceedings

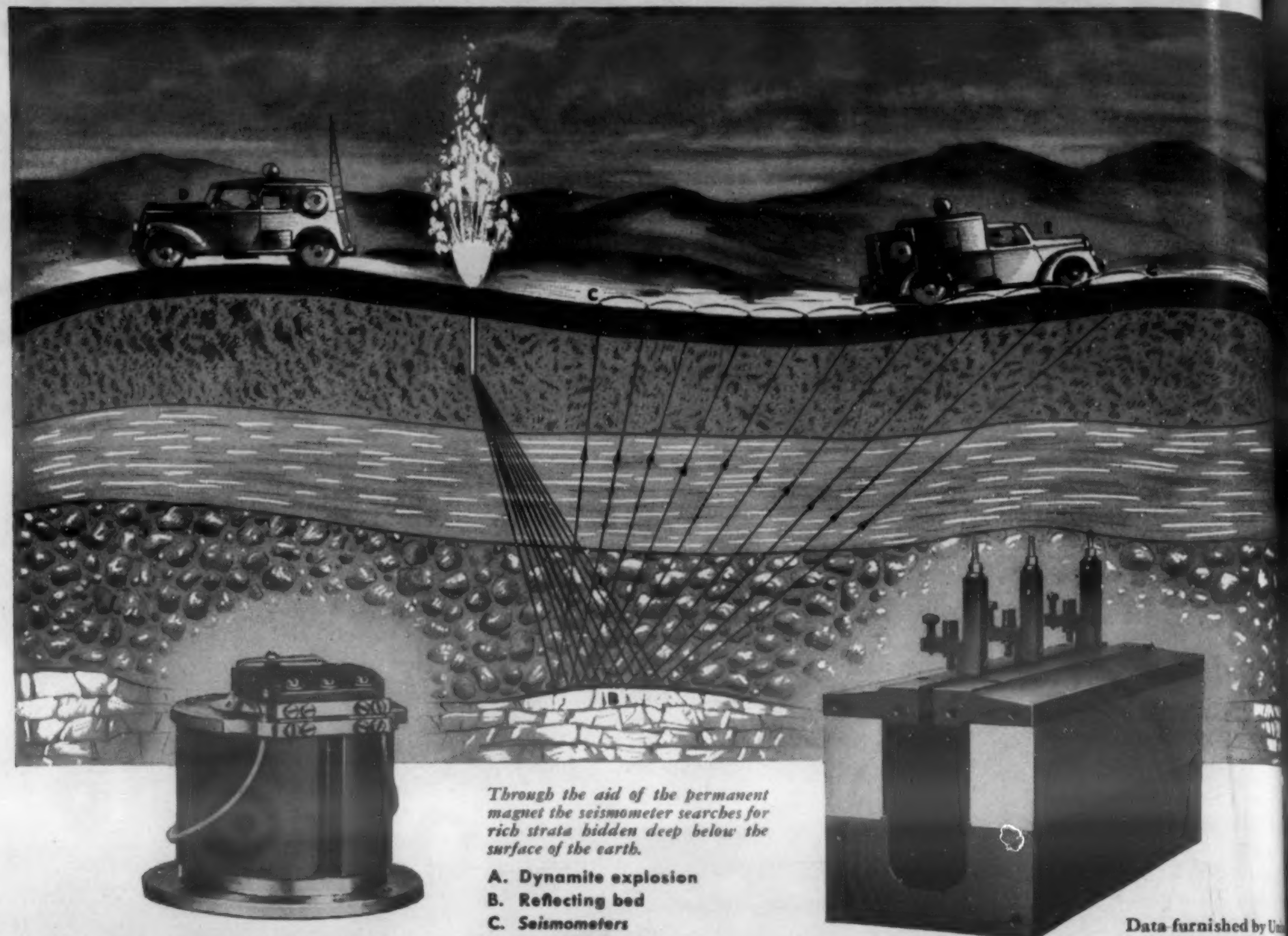
PROCEEDINGS, AMERICAN SOCIETY FOR TESTING MATERIALS (COMMITTEE REPORTS AND TECHNICAL PAPERS) VOL. 45, 1945. *Published by ASTM, Philadelphia 2, Pa., 1946. Fabrikoid, 6¼ x 9¼ in., 1058 pages. Price $12.00 to nonmembers; free to members.*

In this volume are included the various committee reports made during the year 1945, technical papers and their discussions, summaries of symposia on magnetic particle testing and adhesives, as well as a summary of the proceedings of the Forty-Eighth Annual Meeting, the Annual Address by the President, and the Annual Report of the Executive Committee.

The technical papers and some of the committee reports are well illustrated with half-tones; both subject and author indexes are included. The Proceedings is published annually by the Society.

—ROBERT S. BURPO, JR.

THE INVENTORS' MAGNA CHARTA. *By Edwin Hopkins. Published by Edwin Hopkins, 255 W. 43d St., New York, 1946. Paper, 4½ x 6½ in., 268 pages. Price $3.00.* The author of this pamphlet calls for the recognition of the basic rights of inventors and the rehabilitation of the Patent System with 25 new kinds of patents. Numerous incentives are suggested to stimulate invention as are also plans for raising $12,000,000,000 of hazard capital for developing and introducing new inventions and for creating millions of new jobs. It claims to show how to put big business out of business and to do away with monopolies as well as how to depressurize the numerous pressure blocs which "paralyze" Congress. Its 25 chapters cover many important topics.



Through the aid of the permanent magnet the seismometer searches for rich strata hidden deep below the surface of the earth.

A. Dynamite explosion
B. Reflecting bed
C. Seismometers
D. Shooting Truck
E. Recording Truck

Seismometer assembly, showing magnet and bakelite bobbin at top.

Galvanometer Assembly

Data furnished by Un[ited] Geophysical Compa[ny] Inc., Pasadena, Califo[rnia]

PERMANENT MAGNETS HELP REVEAL HIDDEN RESOURC[ES]

Permanent Magnets, once as mysterious as the hidden riches that lie beneath the earth's crust, now aid the geologist's seismometer in exploring the unknown. Permanent magnets serve science, industry and medicine in modern precision controls. Silent and unseen, they contribute their "packaged energy" to the vital functions of radio, telephony, telegraphy, radar, and facsimile transmission.

Millions of magnets serve us daily . . . ranging in size from the tiny midget in the hearing aid to the giant radar magnet . . . each doing some job better. More than 24,000 magnet application[s] have been made by The Indiana Steel Produc[ts] Company, largest sole manufacturers of Perma[-]nent Magnets.

Our engineers will gladly consult with you o[n] any special magnet application. Perhaps perma[-]nent magnets may do some job or process bette[r] in your business or industry. For complete infor[-]mation on magnetic applications, materials, an[d] technical data, please write for our "Permane[nt] Magnet Manual." Your request will receive ou[r] prompt attention.

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ew Materials and Equipment

Cleaning and Finishing Equipment and Supplies

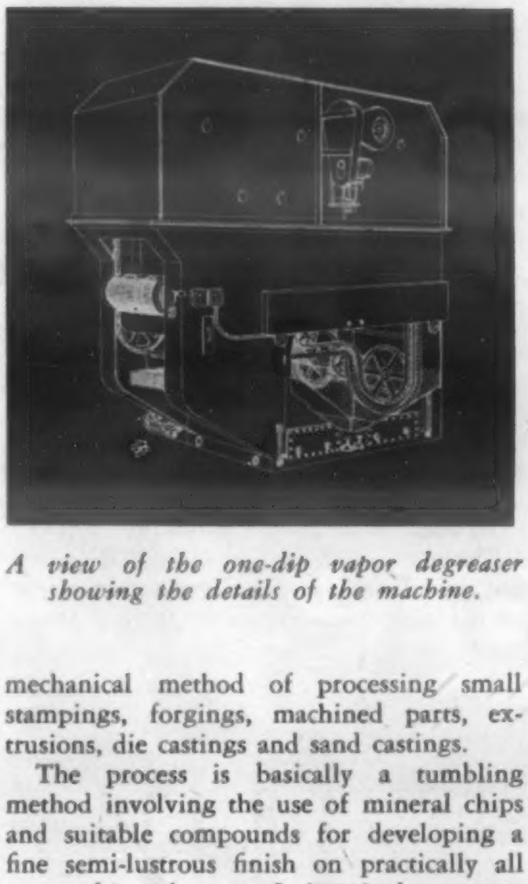
tomotive Vapor Degreasers—The *Phil-s Manufacturing Co.*, 3475 W. Touhy e., Chicago 45, has two new vapor de-easers specially engineered for the auto-tive and aviation industries. The one del, known as Duo, is complete with e-dip tank, electrically heated vapor tank, ntrols and thermostat enclosed in an amelled metal cabinet with cover. It ans by dip, soak or vapor, or any com-nation of these, and is designed to handle sket loads or parts up to 12 in. in dia.

The other model, known as Super, is rge enough to degrease complete motors. is completely contained, and has a pres-re spray hose for flushing stubborn grease d oil deposits. The model also incor-rates a patented feature of reclaiming its n dirty solvent automatically, by dis-llation.

ne-Dip Vapor Degreaser—A new stan-rd conveyorized one-dip concentrator has ecently been introduced to the metal clean-g industry by the *Detrex Corp.*, 14331 Woodrow Wilson, Detroit 32. Called the DC-750, this degreaser is designed to egrease small miscellaneous screw ma-hine parts. The machine occupies less than 5 sq. ft. of floor space and measures 9 ft. in. in height.

The unit may be supplied with rotary r a combination of rotary and flat baskets. Rotary baskets are 10 in. in dia. by 20 in. n length. Work to be cleaned is loaded t one end of the degreaser, carried through he cleaning cycle, and is returned through he upper hood to the same end of the machine for unloading. The conveyor sys-tem is complete with sprockets, shafts, take-up device, speed reducer, and variable speed drive. All of the sprockets below the vapor line are zinc plated, as are all crossrods and conveyor chains.

Mechanical Finishing Process—A new me-chanical finishing process for small parts, called Britehoning, has been announced by The *Sturgis Products Co.*, Sturgis, Mich. It is offered to the finishing industry as a mechanical method of processing small stampings, forgings, machined parts, ex-trusions, die castings and sand castings.



A view of the one-dip vapor degreaser showing the details of the machine.

The process is basically a tumbling method involving the use of mineral chips and suitable compounds for developing a fine semi-lustrous finish on practically all types of metal parts. It is suited as a pre-plating operation for finishing small zinc base die castings or brass stampings prior to bright nickel and chrome plating. Steel and aluminum parts can also be finished by the same procedure.

Parts to be finished can be processed directly after the forming or trimming operation, providing the die marks or stretcher marks do not penetrate too deeply into the surface of the part. Die castings, if closely trimmed, may be processed as received from the trim die, but if the trim-ming is not close, a polishing wheel or abrasive belt operation may be necessary to remove this prior to Britehoning.

Britehoning can be used for the process-ing of items common to the automotive, builders hardware, and plumbing goods industries as well as for sporting goods, general hardware items, tools, etc.

Inhibitor for Sulphuric-Acid Pickling—A new material primarily for inhibiting hot sulphuric-acid pickling solution has been announced by *Oakite Products, Inc.*, 22 Thames St., New York 6.

A yellowish-brown, free-flowing powder with a density half that of water, the new material may also be used in mixed sul-phuric-hydrochloric baths in which sul-phuric acid predominates. Applications possible include pickling many types of ferrous alloys and castings; hot and cold rolled steel; also where pickling is done prior to plating or phosphate coating or where zinc coatings are stripped.

High Vacuum Coating Unit—An indus-trial high vacuum coating unit has been developed by the *National Research Corp.*, 100 Brookline Ave., Boston, Mass., to per-mit mass production of plastic or glass surfaces coated with metallic or low-reflec-tion films. The unit (No. 3103) should be of interest to the metal and plastic industries for decorative coatings and to the optical industry for optical coatings.

The vacuum chamber is a stainless steel cylindrical tank, mounted horizontally, with a door at one end for loading. The inside dimensions, which limit the usable surface, are 48 in. in dia. by 48 in. long. Two 10-in. diffusion pumps, with a combined capacity of 6,000 C.F.M., are manifolded by a 14-in. high vacuum valve and backed by a 100 C.F.M. mechanical pump to reduce the pressure in a clear dry tank from atmos-pheric to 5 by 10^{-4} mm. Hg. in approx-imately 10 min. In production, with charges of plastic pieces, it is expected to run three complete coating cycles per hr.

Filament power is fed into the tank at the top. Six feed-through seals handle three separate circuits, if desired. Thermocouple and ionization gages, located at various points in the system, indicate operating conditions. The central control panel con-tains gage, pump and filament power supply control for convenience of operation.

Enamels for Metal Coating—Enamels, formulated with a modified synthetic rubber base which are chemically resistant, air-drying, high-glass finishes, are now being manufactured by *Maas & Waldstein Co.*, 438 Riverside Ave., Newark 4, N. J. Available in most colors, these enamels, designated Coprene, can be used on steel and most other metals, as well as other products requiring a chemically resistant, air-drying or baking finish. These enamels are also made with metallic powders to produce metal-like coatings and finishes resembling beaten metal.

A new lacquer enamel which air dries to prism-like formations has also been announced by the same company. The coating, named Prismlac, is for use on glass, steel, aluminum, brass and copper. It can also be used on closed grain wood, such as birch and maple.

Core-Plate Enamel Tester—A new core-plate enamel tester designed for measuring the insulating value of enamel coating on sheet steel or steel punchings has been announced by the *General Electric Co.*, Schenectady, N. Y. Consisting of a test head, a hydraulic press and a control unit, the tester provides a standard for measuring the insulating quality of enamels. The instrument is especially useful for testing motor cores as it simulates the conditions of heating and pressure which may exist in a core.

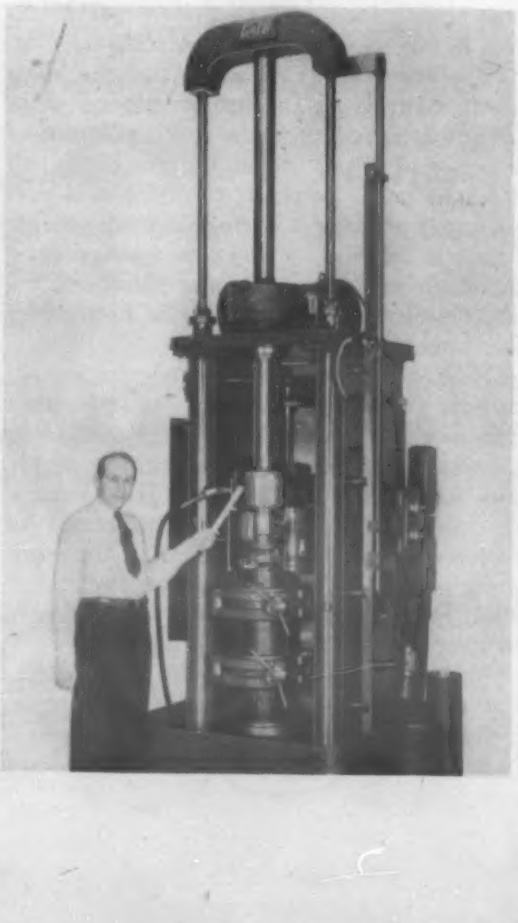
The core-plate enamel tester measuring the insulating value of enamel coating on sheet steel.

Machine Tool Equipment

Vertical Boring Machine—A new vertical boring machine for precision, rough and finish boring of large cylinders up to 40 in. in length and 6 to 8 in. in dia. is announced by *Giern & Anholtt Tool Co.*, 1320 Mt. Elliott Ave., Detroit 7.

The machine, identified as the TR model, has rigidity and accuracy with the spindle piloted directly above the work in a Gatco sealed rotary bushing. It is equipped to bore cast iron, steel or nonferrous tubes using multiple blade boring cutter.

The machine is hydraulically operated and has a feed on 8-in. I.D. tubing of 4 in. per min. in roughing and 4½ in. to 5 in. in finishing. The power requirement on the operation is approximately 10 hp. Adequate coolant provisions are incorporated with the direct flow of the coolant over the cutter for the entire depth of the cut. Fixture is of the self-equalizing type.



This vertical boring machine is particularly suitable for use on large cylinders.

Milling Machines—A new medium sized knee-and-column type milling machine has been announced by the *Cincinnati Milling & Grinding Machines, Inc.*, Cincinnati 9. Designated as No. 2 MI, the machine is powered by a 5-hp. motor, and built in plain, universal and vertical styles. These machines have wide speed and feed ratios of 60 to 1 and 120 to 1, respectively.

Sixteen spindle speeds, ranging from 25 to 1500 rpm., are changed with a single crank type control. The crank operates a hydraulic selector valve, while the actual work of shifting gears is performed hydraulically. While the spindle is rotating a safety interlock prevents the speed change crank from being moved.

Feed rates are changed in the same manner as the speeds. There are 16 feeds, from

to 30 in. per min. The main drive clutch is a single disc dry plate unit, with accessible adjustment. A multiple disc spring-loaded brake, operated by the disengaging action of the starting lever, stops the spindle instantly when the drive clutch is disengaged.

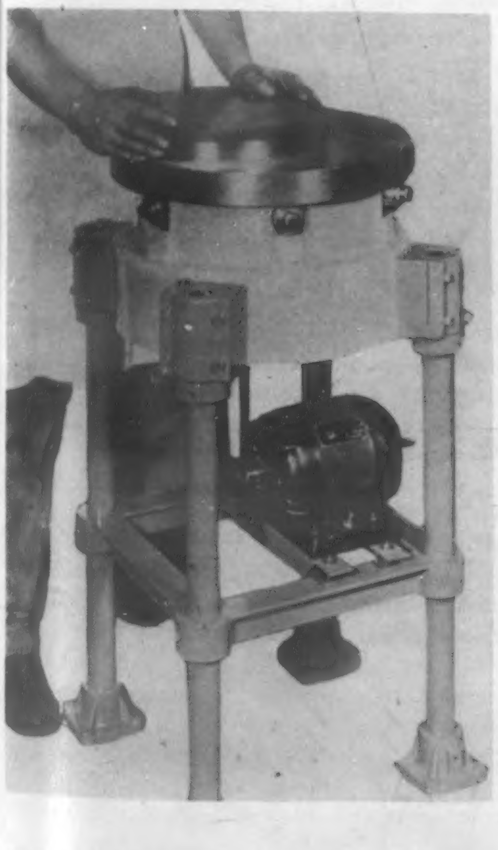
Table ways and parts within the saddle and housing are lubricated by a manual pressure or "oil-shot" system built into the saddle. Arbor support bearings are automatically lubricated by a gravity system, from self-contained dust tight reservoirs. All reservoirs have their own individual glass sight level gages.

Many attachments are available, particularly for horizontal machines. These include circular milling tables, several types of vertical and universal spindle attachments, motorized overarm, and manual controls at the rear operating position.

Flat Lapping Machine—A new machine designed for high-speed precision flat lapping of single parts or production runs of hardened steel, quartz, glass and parts is being produced by *Spitfire Tools, Inc.*, 2933 N. Pulaski Rd., Chicago 41.

The machine finishes pieces to a high polish and precision flat finish and size; it is possible to obtain a surface finish of 2 rms. microinches. Single pieces ordinarily require no holders, chucks or collets. The operator lays the piece on the revolving circular lapping plate and directs its motion with his hands. Production lapping of large quantities of small parts can be done by use of standard or special holders to suit the particular requirements.

The machine has many uses, among which are the precision flat lapping of machine and tool parts, flat sliding surfaces, flat rotating surfaces, air-tight and liquid-tight seals, and flat surfaces on plastic molds, die casting molds and drawing dies.



Surface finishes as fine as 2 rms. microinches are possible with this flat lapping machine.

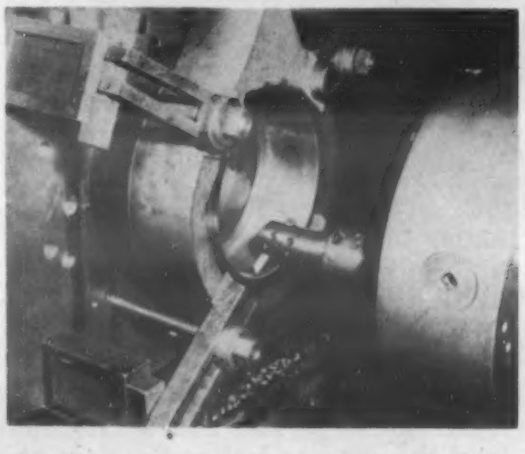
Turntable Fixture for Tapping Units—The *Pond Engineering Co.*, Springfield, Mass., has designed an automatic control unit for converting hand-operated tapping units to automatics to increase the production rate of many small parts.

Indexing, locating, clamping, tapping and ejecting are all accomplished on a turntable fixture, which is actuated by the control unit. Different pieces can be handled on this same machine, by changing the holding blocks on the turntable. Combined operations are possible.

The equipment is primarily a control unit with a 1-cycle, airclutch-operated cam shaft, powered by a 1/3-hp. motor. A minimum of 70-lb. air pressure is required. Four air valves are standard equipment, but additional valves and mechanical cams can be added. Cycle speeds are adjustable from 2 sec. to 1 min., depending upon the operation performed, but longer cycles are available on special order. The frequency and duration of impulses per cycle are adjustable on the air valve cams.

Drill Press Converter—Any size or make drill press can be converted to perform filing, cutting, sawing or slotting operations through use of this converter unit, manufactured by *Leo G. Brown Engineering Co.*, 1157 Riverside Dr., Los Angeles, Calif.

Mounted between two pre-loaded ball-bearings is a solid steel cam, which converts the drill press rotary action to a vertical reciprocating action. The main housing is a Durometal casting with bronze sleeve insert for bearing surface. The cam roller is hardened tool steel.



This picture shows the continuous feed facing head mounted on the boring bar of a floor type horizontal boring machine.

Boring and Facing Attachment—Continuous feed facing and boring head manufactured by the *Giddings & Lewis Machine Tool Co.*, Fond du Lac, Wisc., is designed to simplify a variety of boring, turning, grooving, recessing and threading operations.

This attachment may be mounted either on the spindle sleeve of this company's horizontal boring machine headstock or, with suitable adaptor, on a line boring bar. When the unit is placed on the headstock, the machine spindle extends through the attachment head and operates either independently or simultaneously with the head. By combining machining operations in this way, overall production time can

often be reduced.

If the continuous feed facing head is used with an adaptor and mounted on a line boring bar, machining hard-to-reach surfaces is simplified. The attachment is helpful in machining workpieces that are large and cumbersome and that cannot be easily reset.

A few typical applications for this attachment are: (1) for large open and blind hole boring beyond the range of standard boring tools; (2) for trunnion, stud or similar turning operations; (3) for internal machining of forging dies; (4) for machining both sides of a workpiece simultaneously using two continuous feed facing heads, one mounted on a boring bar, the other on the machine spindle sleeve; (5) for internal and external grinding operations using a special grinder mounted on the tool slide.

Milling Cutters—A new inserted tooth carbide cutter, with blades interchangeable for any type of milling job, is being introduced by the *Wendt-Sonis Co.*, Hannibal, Mo. The cutter is readily adaptable to standard machinery.

The new cutter has an added safety feature in the special type wedge, which prevents blades from slipping out while in operation. When blades need sharpening, they may be easily removed from the cutter body and ground on an ordinary bench grinder. No special equipment is required.

The *Lovejoy Tool Co.*, Springfield, Vt., announces a new face mill. Called the Cutsall, it is a tool-bit-type mill with cemented carbide blades. The housing is built to take either left- or right-hand blades. It holds the blade face slightly back of center so that positive and negative radial rake can be obtained from the same blades.

Blades are tipped with either of two grades of Carboloy cemented carbide; one for cutting steel and one for cutting cast iron and nonferrous metals.

Magnetic-Field Gage for Magnetic Particle Inspection

A new magnetic-field gage, which indicates the relative strength of the magnetic field in parts that are being examined for flaws by the magnetic-particle method of testing, has been announced by the *General Electric Co.*, Schenectady 5, N. Y.

The new instrument is especially useful for testing large castings and forgings in which it is difficult to calculate the field intensity at various points from the current passed through the part and the cross-sectional areas.

In testing parts for flaws with the magnetic-particle method, a magnetic field is first set up in the part. Then magnetic particles are distributed over the surface of the part, and these line up along any crack or flaw. However, it is possible for a defect to be present even though not indicated by the magnetic particles if the magnetic field is not strong enough to

The Wand That Makes 2=1

(IT'S PHOSPHOR BRONZE)

The wand in the welder's hand is a shielded arc electrode made of Riverside *Phosphor Bronze.* It is manufactured by one of Riverside's customers, whose name has been synonymous with scientific achievement in arc welding for more than forty years. Almost like a magic wand, the electrode, when properly employed unites copper, brass and many types of bronzes which are difficult to braze.

Phosphor Bronze is also used for building up and filling in bronze castings and surfaces of steel or cast iron. It leaves a dense high strength deposit of uniform structure. It is strong and non-corroding under widely varying temperatures and pressures.

Riverside produces *Phosphor Bronze* in many alloys, three of which—Grades "A", "C", and "D" are adaptable to welding. Any one of these alloys may be the specific solution to your problems and serve to retain the good will of your customers. Write for literature, today, also get complete information about *Nickel Silver* and *Beryllium Copper.*

INSIDE RIVERSIDE—*Our customers asked us to solve a serious problem. They were losing too much "down time" on their equipment because of small welding rod coils. It was imperative that the size of the coils be increased. Frankly, we did not believe we could crack this tough problem, but in jig time our engineers conceived and developed an original method for handling large heavy coils. We now supply these and everybody is happy.*

RIVERSIDE

THE
RIVERSIDE METAL COMPANY
NEW YORK CHICAGO RIVERSIDE • NEW JERSEY HARTFORD CLEVELAND

bring out the particle pattern, and often identical flaws will appear as different sizes and thus give inconsistent results.

The magnetic-field gage assures a magnetic field that is sufficiently strong to bring out the particle pattern, so that defects of the same size give similar indications. By giving a direct indication of field strength, it permits standardized testing at fixed field intensities. This gage measures both alternating-current and direct-current field strength.

The instrument consists of a gage head which is permanently attached to a field strength indicating unit. The head consists of small coils wound around a U-shaped laminated metal core mounted in a plastic handle. Pole shoes are attached to the ends of the core, and these make contact with the piece being tested.

In operation, the pole shoes are placed in contact with the test surface. Direct or alternating current is then applied to the part in accordance with the regular magnetic-particle method. The current is increased or decreased until the magnetic-field gage indicates the desired field units for the particular test.

The magnetic-field gage being used to indicate the relative strength of the magnetic field in a large metal part.

Grid Bearings

Grid bearings for heavy load applications such as connecting rod and main bearings have been placed in production by *P. R. Mallory & Co., Inc.,* Indianapolis, Ind. The bearings consist of a steel backing lined with gridded silver or copper. The indentations are filled with lead.

Actual tests have shown that grid type bearings compare favorably with other bearing materials in the basic bearing properties, namely: score resistance, fatigue resistance, corrosion resistance, and embeddability.

Grid type bearings have been tested in a great many applications with satisfactory results, and they have been used in production in a number of cases, although they were not developed soon enough to be used extensively during the war.

One of the most striking applications was in a small radial aircraft engine adapted for use in tanks. This engine had been designed to use copper-lead master rod and

main bearings, which operated satisfactorily in aircraft, but when used in tanks, due to the great quantities of dirt and sand which entered the engine, the bearings wore so much in a few hundred hours that they had to be replaced. When silver grid bearings were installed in these engines, the bearing life was so increased that in many cases the bearings outlasted the machine. These bearings operate at a load of approximately 3,000 psi. and at a maximum speed of 2400 rpm. against a hardened steel shaft of 275 to 300 Brinell.

Electronic Micrometers

Carson Micrometer Corp., Newark, N. J., announce production of four redesigned models of their electronic micrometers for precise thickness measurement in the shop or laboratory. A feature of these models is the electronic circuit used in conjunction with the micrometer screw thread. Electronic discrimination thus replaces the human sense of touch, and accurate readings to 0.00005 in. on production testing lines are said to be possible.

These instruments will measure thickness of compressible or non-compressible materials as well as conducting or non-conducting materials. Their precision is unaffected by variations in temperature, line-voltage, vibration or aging of electronic tubes. Units are portable and weigh but 20 lb. complete.

Model L, designed for pressureless measurement of conducting parts, is being used for inspection, sorting, grading and measurement of machined parts, ball bearings, radio tube grids, small assemblies and depth of counterbore, as well as deflections of diaphragms and springs.

Model M was developed for measuring diameter and out-of-round condition of fine, soft-annealed wire. It will register precise dimensions of paper, ribbon, strip, foil, cork, rubber, felt, plastic, linoleum, photographic film and textiles.

Model W is for pressureless measurement against conducting surfaces, used in the laboratory measurement of deflections and drift in springs, diaphragms, bi-metal elements, bellows, and similar applications requiring measurement without pressure.

Model S is for production testing of tension and compression springs; set testing of diaphragms and metal bellows, flat springs and thermostatic elements.

X-Ray Diffraction Camera

Availability of a new X-ray diffraction camera which permits study of minute sections and the charting of changes over microscopic areas has been announced by *North American Philips Co., Inc.,* 100 E. 42nd St., New York. This new instrument is especially useful in research laboratories.

Designed to fit the Norelco X-ray diffraction unit, the camera comprises a precision-machined body which is removable from its carriage for loading. Special features permit removal and replacement without loss of alignment.

Two specimen holders are provided, one comprising a special positioning and tensioning device for fibres, narrow strips or similar objects. The other holder utilizes a flat plate insert to accommodate microtomed sections, etc. A special film cassette with beam stop is provided and a hose connection on the body permits gas filling or pressure reduction.

Accessories include an additional smaller pinhole system, ring adaptor to be used on microscope when adjusting specimen in camera, extra spacing insert for film cassette, adjusting wrenches and film punch.

Rotating Pan-Type Mixer

A new rotating pan-type mixer has been developed by *Ransome Machinery Co.*, 1401 S. 2nd St., Dunellen, N. J., for a variety of uses in industries requiring mixing, blending, tumbling, polishing, finishing, and similar operations.

The rotating pan is motor-tilted and motor-rotated at constant speed. A variable speed drive can be furnished where materials handled require the rotating speed to vary. The pan is of all metal construction with joints welded and ground smooth. For mixing or blending two or more ingredients, mixing blades are added as necessary, to assure thoroughly mixed, uniform batches.

With a 135 deg. tilting range, materials are completely and cleanly discharged from the rotating pan. Safety limit switches are installed at the two extreme ends of the tilting range. The unit is operated by remote push-button control.

This mixer is useful for such operations as mixing, blending, tumbling and finishing.

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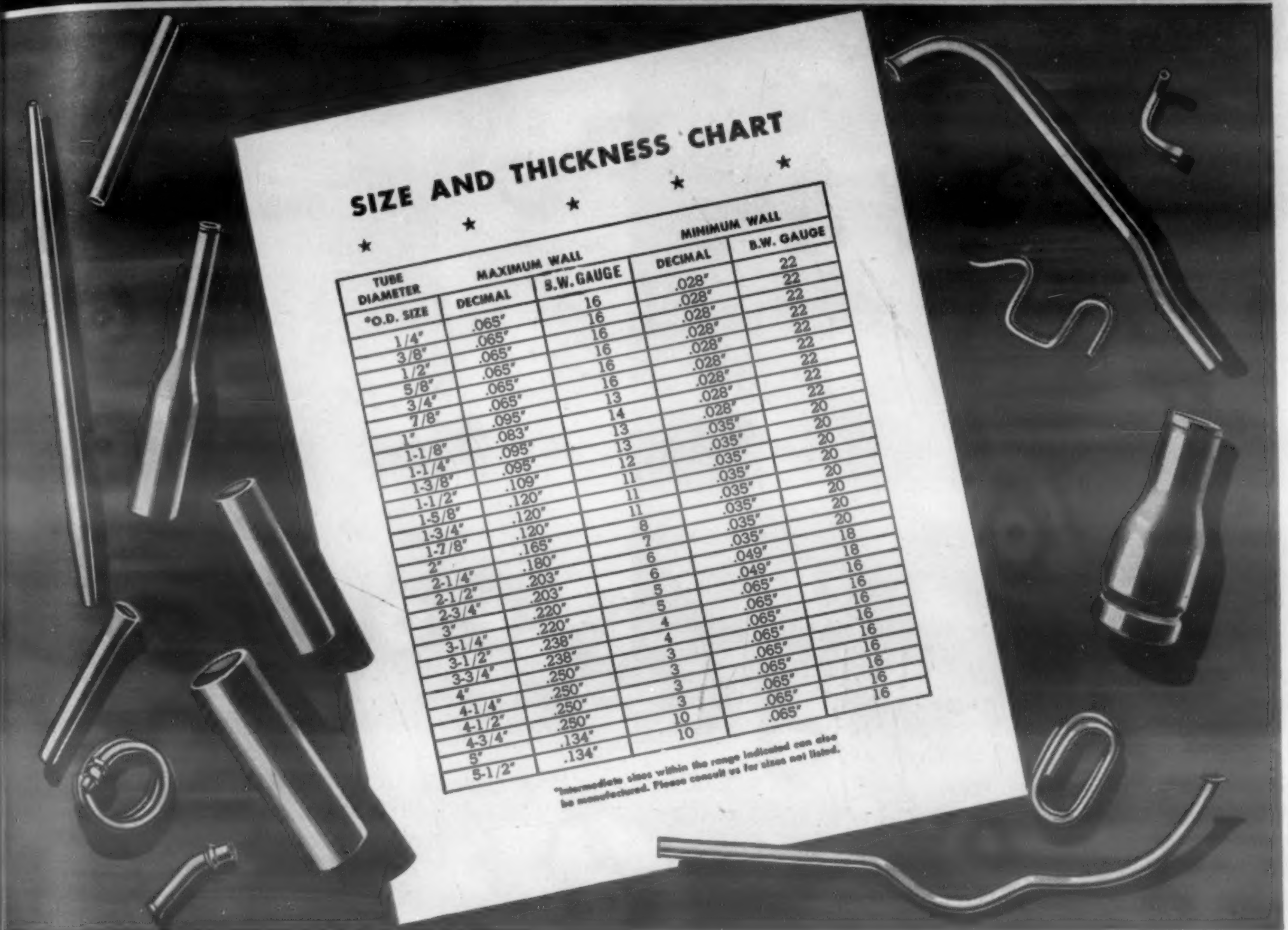
ELECTRIC WELDED STEEL TUBING

Fabricated Tubular Parts for Mechanical, Pressure and Structural Applications



SIZE AND THICKNESS CHART

TUBE DIAMETER	MAXIMUM WALL		MINIMUM WALL	
*O.D. SIZE	DECIMAL	B.W. GAUGE	DECIMAL	B.W. GAUGE
1/4"	.065"	16	.028"	22
3/8"	.065"	16	.028"	22
1/2"	.065"	16	.028"	22
5/8"	.065"	16	.028"	22
3/4"	.065"	16	.028"	22
7/8"	.065"	16	.028"	22
1"	.095"	13	.028"	22
1-1/8"	.083"	14	.028"	22
1-1/4"	.095"	13	.028"	22
1-3/8"	.095"	13	.035"	20
1-1/2"	.109"	12	.035"	20
1-5/8"	.120"	11	.035"	20
1-3/4"	.120"	11	.035"	20
1-7/8"	.120"	11	.035"	20
2"	.165"	8	.035"	20
2-1/4"	.180"	7	.035"	20
2-1/2"	.203"	6	.035"	20
2-3/4"	.203"	6	.049"	18
3"	.220"	5	.049"	18
3-1/4"	.220"	5	.065"	16
3-1/2"	.238"	4	.065"	16
3-3/4"	.238"	4	.065"	16
4"	.250"	3	.065"	16
4-1/4"	.250"	3	.065"	16
4-1/2"	.250"	3	.065"	16
4-3/4"	.250"	3	.065"	16
5"	.134"	10	.065"	16
5-1/2"	.134"	10	.065"	16

*Intermediate sizes within the range indicated can also be manufactured. Please consult us for sizes not listed.

With every year that passes, more and more manufacturers of products calling for ELECTRIC WELDED STEEL TUBING are discovering the advantages of specifying the "Standard" brand. They find that our wide variety of shapes and sizes, plus our facilities for high speed production afford them the means of getting the kind of tubing they want—when they want it. And they find that our interested and willing cooperation in the solving of special tubing problems helps them make their products quicker and at lower cost. These same advantages are available to you. If you are looking for a source of high quality ELECTRIC WELDED STEEL TUBING it will pay you to investigate our experience and facilities.

THE STANDARD TUBE CO.

Detroit 3, STANDARD Michigan

Welded Tubing *Steel Forgings*

★ *Complete Tube Stocks Maintained by* ★

STANDARD TUBE SALES CORP., One Admiral Ave., Maspeth, L. I., N.Y.
LAPHAM-HICKEY COMPANY, 3333 W. 47th Place, Chicago 32, Ill.
UNION HARDWARE & METAL CO., 411 E. First St., Los Angeles 54, Cal.

Machine for Grinding Sand Core Faces

A portable production machine for grinding sand core faces before pasting cores together and thus producing a uniform accuracy not possible by hand filing or scraping of cores has been announced by *D. J. Murray Manufacturing Co.*, Wausau, Wis.

The machine will handle a large range of core sizes and is furnished complete with 1-hp. motor. It requires floor space for 3 ft. by 5 ft. for operation. The grinding head is adjustable and locks firmly in any position. Small cores can be mounted in multiples in gang fixtures, so that it has a large daily capacity on cores of one run, or it can be changed over for small runs of various cores.

Mounted on large casters, it is a portable unit that can be placed in any position or any part of the core room. Maximum clearance between face of the table and face of grinding wheel is 18 in.

A large range of core sizes can be handled in this sand core face grinding machine.

Heavy-Duty Selenium Rectifier Stack

Improvements in the design and efficiency of selenium rectifiers, incorporated in a heavy-duty stack, are announced by *Federal Telephone & Radio Corp.*, Newark, N. J. This new selenium rectifier stack is said to be the only stack currently available that has a double studs, center contact construction and 26-volt plates.

Employing rectangular, square-cornered plates instead of the round type, the new stack is designed to mount either in a vertical position or in a horizontal position, thereby affording improved and unobstructed circulation of air for plate cooling. One of the new rectangular plates more than takes the place of two of the 4⅜-in. dia. plates.

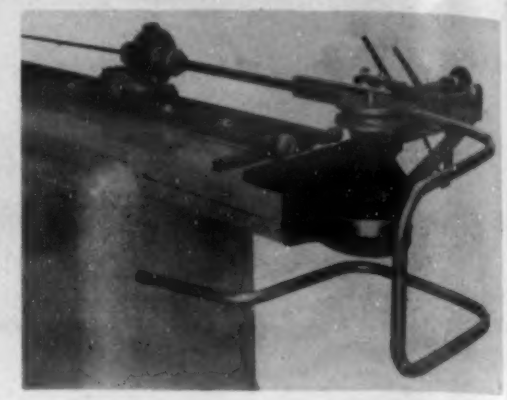
The uses for this stack include such fields as arc welding, aviation equipment, cathodic protection, electroplating, and anodizing.


. . . .Smooth sailing
ALUMINUM REFINERS

Tube Bender

This new model tube bender manufactured by *Leonard Precision Products Co.*, 1100 Larson Ave., Garden Grove, Calif., has a capacity of 3/8-in. to 1 1/2-in. ferrous or nonferrous tubing. It is hydraulically operated. From 1 to 10 bends may be made in a single length of tubing with one setting.

This new unit is designed for any production bending operations requiring multiple bends per tube and duplicate parts such as steel furniture frames, air conditioning, refrigeration, automotive and aircraft tubing.



This picture shows the tube bender in the process of shaping a piece of tube.

Equipment for Measuring Surface-Finish

The *Brush Development Co.*, 3405 Perkins Ave., Cleveland 14, has announced a new model instrument (Model BL-103 Surface Analyzer) for measuring surface-finish. It can be used to check surface finishes from less than 1 to 5000 microinches. Exploration is done with a fine diamond point, and a chart record can be made of the surface finish on a direct-inking oscillograph.

Accessory equipment includes a meter, which provides a visual check of "RMS" surface roughness where chart records are not needed. Some of the uses of this instrument are measuring surface finishes of metals, glass, plastics, paper, plated and painted surfaces.

The *Physicists Research Co.*, Ann Arbor, Mich., announces a new reading recorder for those who need a written record of the surface roughness measurement of a part. Operating as an attachment to the company's instrument for measuring surface-finish, the Profilometer, it provides a continuous chart record of the average roughness of the surface being measured.

The charts, which are read in microinches, are useful in obtaining more detailed information on surface roughness, such as the location of rougher or smoother areas, and in supplying customers with records of the surface finish on parts delivered to them.

Copper-Base Alloy Electrode

A new, coated beryllium-copper elec- known as Beryl-Trode, is the latest cop- base alloy electrode offered by *Ampco M- Inc.*, 1745 S. 38th St., Milwaukee 4, W- These electrodes have a medium we- flux coating required for stabilizing arc. They can be used with either metallic- or carbon-arc process.

The electrode is designed to weld p- made of beryllium-copper, such as resista- welding jaws, seam welder wheels, etc. T- deposits, when heat-treated, develop hi- hardness, high-strength values similar the base metal. These electrodes are u- for joining, repairing cracks or defects castings, and for building up of worn s- faces. They are made in two diameters o- —5/32 in. and 3/16 in., in 14-in. lengt-

This peening and scaling hammer is con- venient for such jobs as removing scale and rust from the inside of cylindrical parts

Pneumatic Peening and Scaling Hammer

A new air-powered peening and scaling hammer, Model 7002, is announced by *The Aro Equipment Corp.*, Bryan, Ohio. This tool is a hammer-type tool for removing scale and rust on welded parts. It can also be used for removing sand on small castings and peening tubular rivets and other small parts.

The tool delivers 5,000 blows per min., yet will not distort light sheet metal when removing scale. The piston and cylinder are of alloy steel, precision ground. Over-all length of the hammer head is $2\frac{1}{8}$ in., and the tool is 7 in. in length. It is small enough to get in the hard-to-reach places.

The connection between the hammer head and body can be any desired length. Body of the tool is cast aluminum with automatic throttle valve.

Metal Forming Brake

The *O'Neil-Irwin Manufacturing Co.*, 382 8th Ave. South, Minneapolis, Minn., announces a new development, the Di-Acro Brake No. 4, which will duplicate parts accurately in ductile materials such as copper, bronze, stainless steel, aluminum, bi-metals and sensitized materials.

The machine has a special material clamping action for making sharp bends; the double-edge vertical folding plate makes possible close reverse bends, and an adjustable material gage is said to assure precision in all duplicated parts.

The original contact surfaces can be changed on the job, thus increasing the working range of the unit to cover the forming of special and complicated parts. It is claimed that small parts, normally produced by large hand or power operated brakes, can be formed on this model to advantage, since this smaller unit gives greater precision and higher production than is generally possible with larger machines.

A metal forming brake that can be used to duplicate parts out of a variety of ductile materials.

Resistance Type Soldering Tool

A resistance type soldering tool has been designed by *Luma Electric Equipment Co.*, Toledo 1, Ohio, with two power unit models and choice of eight basic single or double carbon electrodes. The equipment is applicable to precision work and to heavy industrial operations.

This type of tool offers the advantages that no pre-heating period is required, and that the operating current is in use only when contact of electrode with job is made. A 10-watt energizing current is used when not soldering.

Work capacity with this resistance type tool is said to be high. Another feature is that on light work where the small diameter electrodes are used, by attaching the required number of electrodes two or more operators may safely and conveniently work from the same power unit with no differential in time or quality of work.

Generators for Induction Heating

Two companies recently announced additions to their line of equipment for induction heating.

Two new models of induction-type electronic power generators, of 2 and 15 kilowatts output, respectively, for localized heat treating, brazing, and soldering of metals are now in production by the *Engineering Products Department, Radio Corp. of America,* Camden, N. J.

Both of the new power generators are electron tube units designed for the conversion of electrical power from the commercial 60-cycle supply to a frequency of approximately 400,000 cycles per sec. The 2-kw. and 15-kw. generators, designated as the 2-BL and the 15-BL, are each composed of two units, the main generator unit and an applicator unit.

The main generator unit houses the high-voltage rectifier, the main control and protective devices, and most of the high-frequency components. The applicator unit houses the output current transformer and its associated high-frequency elements. It is connected to the main generator by 25-ft. cables, permitting the location of the applicator unit in any desired work position within a radius of 25 ft. of the main generator.

Model "1400" is the newest high-frequency induction heating generator, manufactured by the *Induction Heating Corp.,* 389 Lafayette St., New York 3. When fully loaded, this unit is capable of delivering an output of 1400 B.t.u. per min., or approximately 25 kw. at a nominal frequency of 375 kilocycles into a piece of work. It has a full-load input of 50 kva. at 90% power factor, and operates on a 205-245 volt, 60-cycle, three-phase power supply. Since line voltages of 550 or 440 volts are common in some plants, provision is made for reducing these voltages to 220 volts through installation of a transformer between the line and the generator.

The tube complement of this generator consists of two water-cooled oscillators and six rectifiers. These tubes are protected against damage by a new, patented time-delay water system. This device automatically keeps water flowing through the water jackets of the tubes after the generator is turned off.

This unit can be used as a heat source for brazing, soft soldering and fusing, as well as for hardening, annealing, tempering, stress relieving, forging, melting, shrink fitting, debonding, and expanding.

Oxygen Determination in Molten Iron and Steel

New oxygen determination apparatus for the analysis of the oxygen content of open-hearth melts has been developed by *Central Scientific Co.,* 1700 Irving Park Rd., Chicago 13. With this equipment oxygen determination can be made while the heat is still in the finishing period.

In the procedure, a sample is poured into a specially designed mold. A piece of

this sample is weighed and introduced through a mercury vacuum lock into an induction furnace operating under vacuum. At a temperature of 2800 to 3000 F the sample melts in 20 sec., and all oxides are reduced by the carbon present in the graphite furnace crucible. Resulting carbon monoxide is then accurately measured, and the percent oxygen is computed from a simple equation.

The apparatus is inclosed in a steel frame, protected both electrically and mechanically. An Ajax-Northrup high-frequency converter, operating at 220 volts, 60 cycles, supplies the power for the induction furnace.

Ductility Testing Machine

The *Steel City Testing Laboratory*, 8843 Livernois Ave., Detroit 4, announces a new model ductility testing machine. There are two types: a Model PA-2 with a 15,000-lb. capacity for stock up to ⅛ in. thick; a Model PA-3 with a 30,000-lb. capacity for stock up to ¼ in. thick.

The permanent head is piloted to the main cylinder body. This provides for the upper grip held in the head and the one mounted on the piston always being completely concentric and for the penetrator starting the cupping at the exact center of the opening in the grip. Another advantage of the multiple piston construction of these machines is that the specimen is automatically held between the grips with a load in proper proportion to the one being applied in forming the cup.

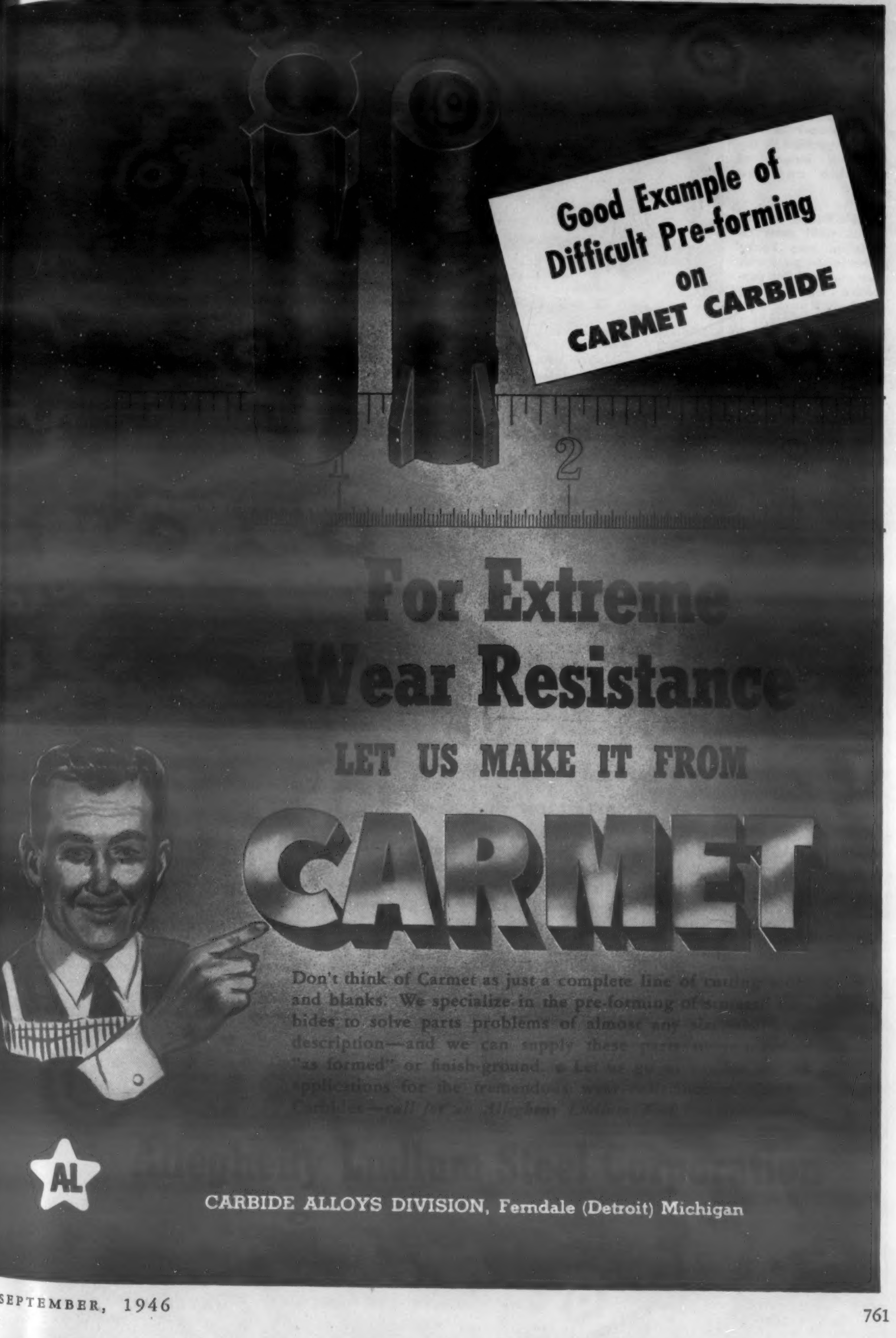
Operation of the machines consists of placing the specimen in the opening between the grips. The load is applied automatically and uniformly to grip the specimen, followed immediately by the penetrator forming the cup. Then reversing the control valve releases the pressure and all functioning parts return to their original position and the specimen is removed. Cupping tools and dies are supplied to suit the various thicknesses of stock.

Extruded Coating for Self-Hardening Electrodes

A new extrusion coated self-hardening electrode has been announced by *Air Reduction Sales Co.*, 60 E. 42nd Street, New York 17. Manufactured by the *Stoody Co.*, this electrode is said to have good arc characteristics, working equally well with either an a.c. or d.c. machine.

Some of the advantages cited for the self-hardening electrode are: no slag interference; more rapid deposition rate than dipped type electrodes; can be applied in all positions; no loss of hardness or wear resistance on multiple layers; solid dense deposits with a minimum of porosity; satisfactory application within a wide range of amperages.

Typical applications of the self-hardening electrode include hard facing in building up worn areas of tractor lugs, shovel teeth, manganese steel crushing equipment, hampers, dredge pump casings, wobblers, clutches, spindles, coupling boxes, bulldozer blades and various other equipment.

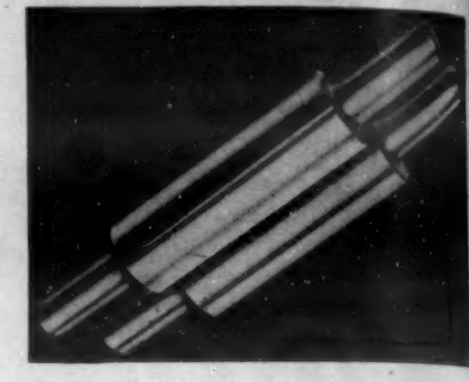


Good Example of
Difficult Pre-forming
on
CARMET CARBIDE
1
2
For Extreme
Wear Resistance
LET US MAKE IT FROM
CARMET
Don't think of Carmet as just a complete line of
and blanks. We specialize in the pre-forming of
bides to solve parts problems of almost any
description—and we can supply these
"as formed" or finish-ground.
AL
CARBIDE ALLOYS DIVISION, Ferndale (Detroit) Michigan

Tungsten Carbide Rolls for Cold Metal Strip Mills

Kennametal Inc., Latrobe, Pa., has announced the development of solid tungsten carbide rolls for cold metal strip mills.

The characteristics of these rolls include high strength and hardness for long-wearing qualities under heavy loads; high modulus of elasticity—two to three times that of steel—for resisting deflection under high pressures; uniform, close-grained physical structure which gives the rolls a high polish and which is imparted to the strip.



These solid tungsten carbide rolls have high strength and hardness characteristics.

The torsion strength of these rolls is said to be superior to carbon steel and only slightly inferior to alloy steels. Their resistance to pick-up of carbide grains that roughen the surface enable these rolls to hold their high luster.

Kennametal rolls are producing a 1.5 micro-inch finish on nickel strip and it is reported that equally good results are attainable in rolling carbon and stainless steel.

Perpendicular Type Dial Indicator

A new type of universal indicator constructed with the dial perpendicular to the axis of the body of the instrument has been put on the market by *Federal Products Corp.*, Providence, R. I. The perpendicular location of the dial makes this indicator useful for general machine shop, tool room and inspection jobs. The instrument is especially adaptable for jig borers, and also for certain drill press and milling machine applications, where the perpendicular position of the dial greatly improves readability, resulting in greater accuracy. Dovetails, friction clamps and rods provide for the setting of the indicator to check a wide range of hole sizes, with the dial in a horizontal position.

Models 5 and 6 (English) are graduated .001 in. and .0001 in. respectively. Models 7 and 8 (Metric) in .0024 mm and .01 mm respectively. The instrument has simple direct combination of lever and crown gear movement and jeweled bearings.

Diesel Engine-Driven Arc Welder

The *Hobart Brothers Co.*, Troy, Ohio, announce a diesel engine driven arc welder of 300-ampere capacity, especially made for use in locations where electric power is not available.

The welder is equipped with controls that permits the operator to make volt-ampere adjustments right at the work. Other features of the welding generator include separate excitation and two way ventilation.

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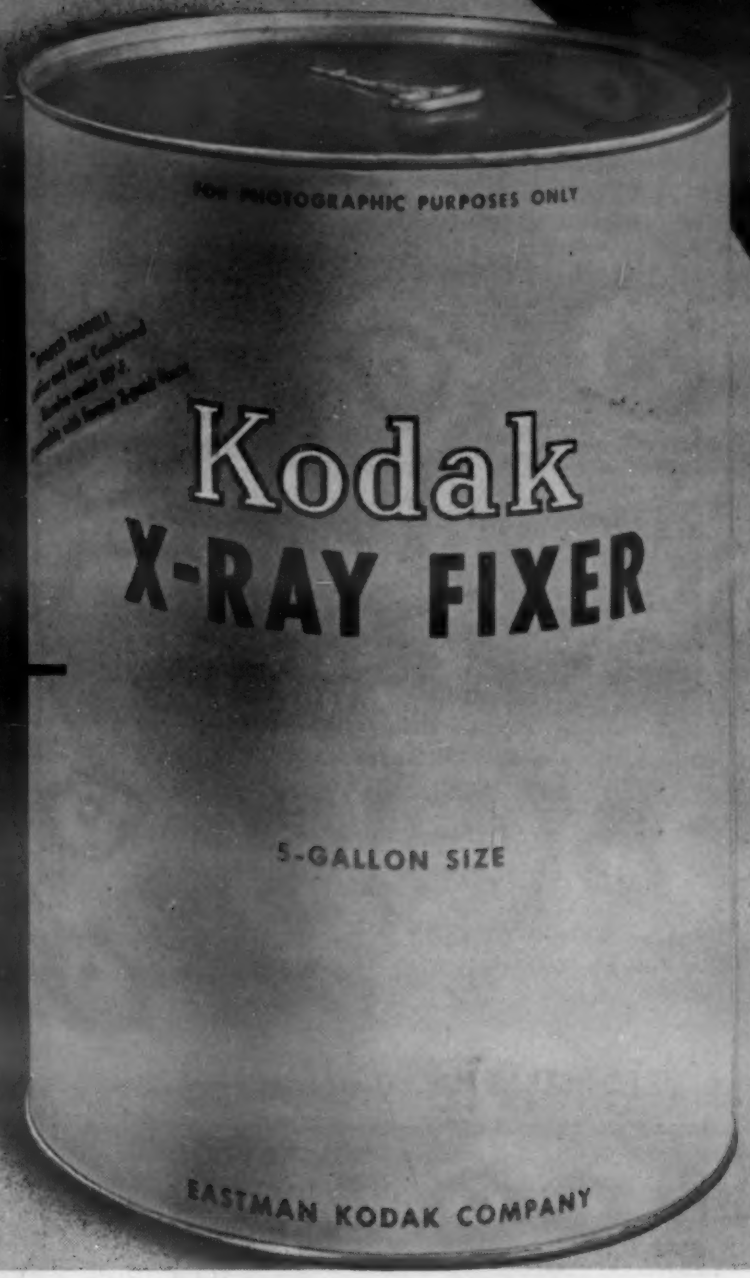
Single-Powder
-Ray Fixer

w Kodak X-ray Fixer eliminates
ed for *two* powders . . . is easy
mix, quickly soluble



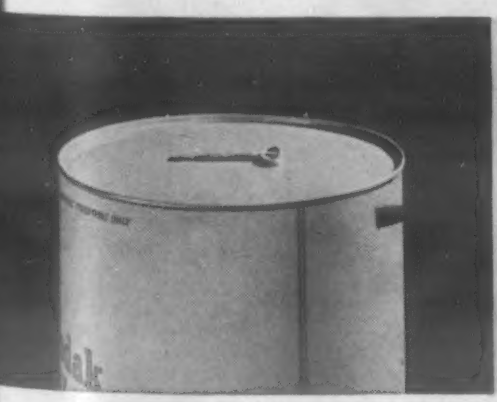
F you're a radiographer, you're pretty sure to be enthusiastic about this new formula developed Kodak's research laboratories. Here's why . . .

. . it gives you—in *one* powder—all the ingredients necessary to fix and harden x-ray film.

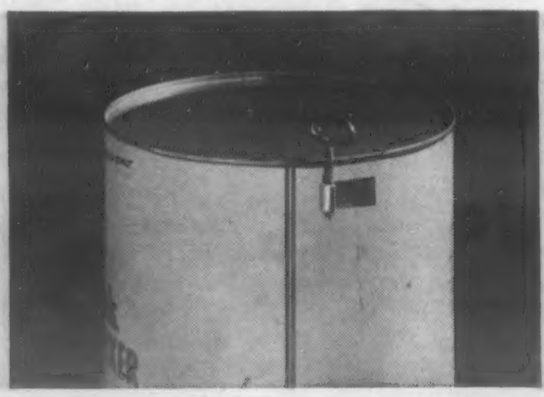
. . it simplifies your darkroom routine . . . saves you the time and trouble of dissolving two powders separately . . . then combining the two solutions.

. . . it's as simple to prepare as a liquid fixer . . . yet has the uniform high quality, the long life, low stain potential, and low cost of the old multiple powders.

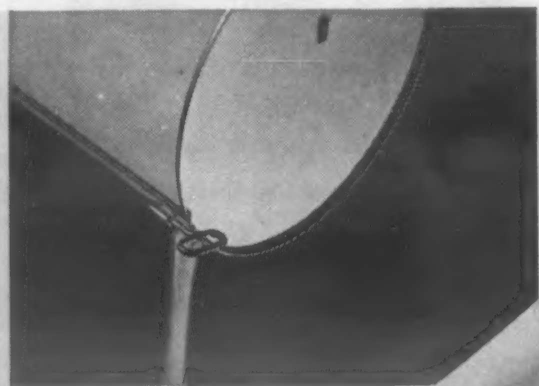
Available now in five-gallon and one-gallon sizes, Kodak X-ray Fixer comes to you in cans which are hermetically sealed but easy to open. Order this single-powder fixer from your x-ray dealer—you'll find it will make your film processing *easier*.



t's sealed for safety . . ..



It's easy to open . . .



The powder flows freely . .

ASTMAN KODAK COMPANY
-RAY DIVISION • ROCHESTER 4, N. Y.

Kodak

The welding generator has a rating of 300 amperes at 40 volts. Current range for welding duty is from 20 to 40 volts, 60 to 375 amperes. It is a single operator variable voltage type, with 4 laminated main poles and four interpoles (commutating poles). Pole pieces are removable. This unit also has oversize, 4-pole exciter built in on main shaft that insures quick arc recovery and build up, and eliminates accidental polarity reversal.

The entire unit is enclosed in a steel canopy with hinged side panels and door latch that allows the panels to snap closed. The welder (stationary model) weighs 2,637 lbs. dry and can be mounted on wheels, trailer or truck for easy portability.

This company also announces a new welding booth for production welding.

The booth is 9½ ft. wide, 9¼ ft. deep and 7 ft. high, constructed of fabricated panels of 16 gage sheet steel formed with companion flanges, punched on 12 in. center for bolting assembly. The door is the sliding type with overhead track, and measures 43 in. wide by 78 in. high.

Metal Forming Presses

A new 100-ton capacity single action press has been added to the line of metal-forming presses produced by *Watson-Stillman*, Roselle, N. J. It provides a number of methods of control for correct metal-forming. Control is provided for both manual and automatic single cycle operation with reversal by either pressure or position. Position is controlled by adjustable slowdown. Also, inching control is arranged for die setting. In addition, it has full-range adjustment control of pressing speed.

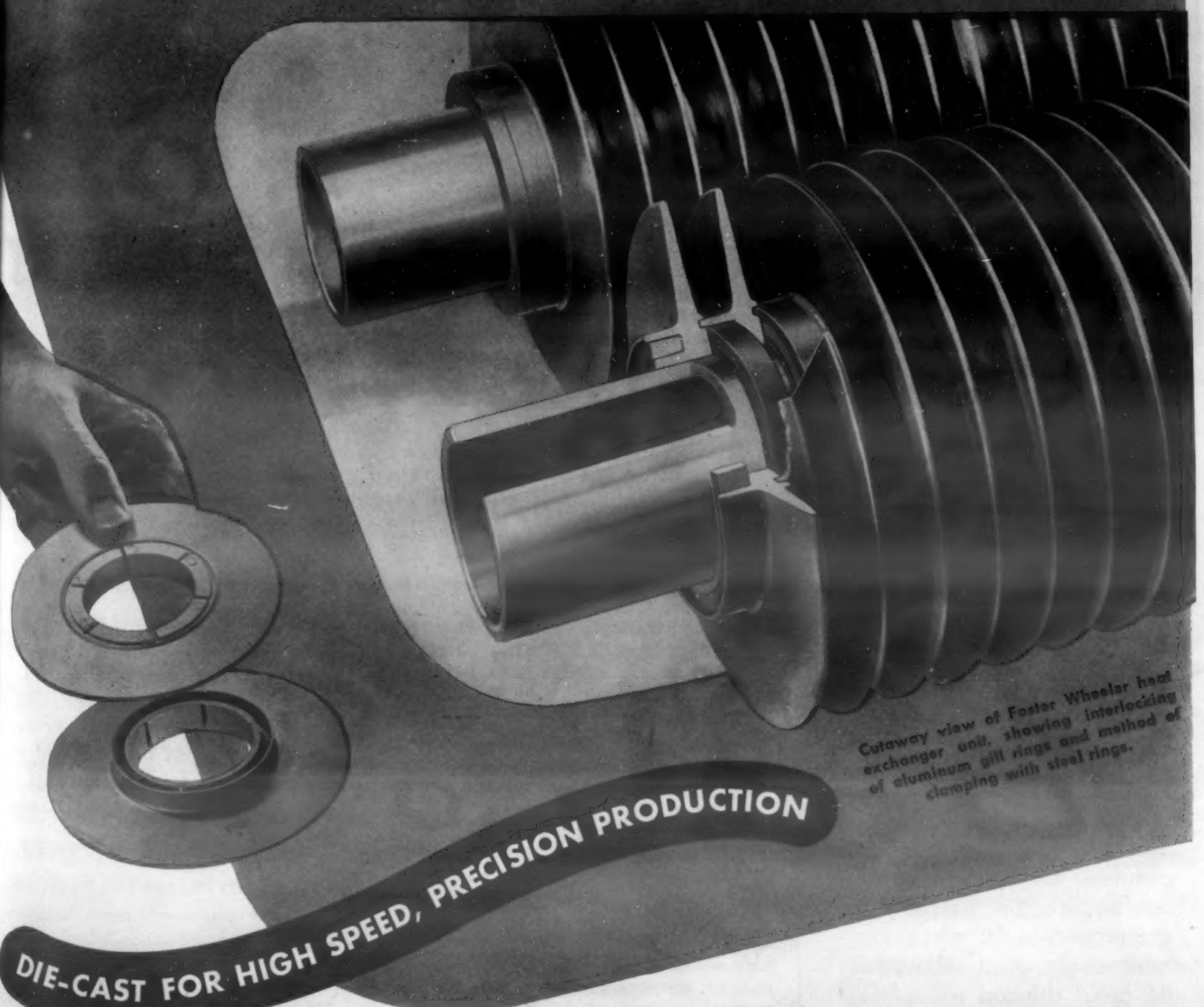
This machine has a prefill system for a rapid transverse stroke. It comes with a cooler for maintaining oil at proper operating temperature. Among standard equipment are two radial piston type pumps connected to a 100-hp double end ball bearing motor as a pumping unit. Operating speeds are 775 in. per min., advance; 225 in. per min., pressing; 775 in. per min., return.

The same company has also announced a new 500-ton fully hydraulic hobbing press for precision hobbing and die-sinking. The platens are of open-hearth steel castings with surfaces tooled to a smooth finish and accurately bored for the columns. They are suitable for full capacity loads on a small area. The cylinders are constructed of open-hearth steel, the columns of steel forgings, and the rams of close-grained iron castings.

● A new portable pyrometer kit has been introduced by *Wheelco Instruments Co.*, 847 W. Harrison St., Chicago 7. The kit, known as Model 2863, is compact and light-weight, containing a high resistance portable pyrometer, a straight type extension with adapter for iron-constantan surface thermocouple, and an assortment of thermocouples. An additional adapter is furnished for use with the bare and prong thermocouple tips, which are also included in the kit.

Gill rings of Alcoa Aluminum

FOR RAPID HEAT TRANSFER AND LONG LIFE



Foster Wheeler Corporation uses Alcoa Aluminum gill rings on its economizer tubes to reduce weight and space. The reduction in space is due to two characteristics of aluminum—the ability to provide more surface per foot and the higher rate of heat transfer. (An economizer recovers heat which would otherwise be wasted up the stack, and uses it to raise the temperature of boiler feedwater.) Aluminum's high heat conductivity speeds the transfer of heat into the water.

Aluminum's high resistance to corrosion helps account for the long life of these economizers.

Die-cast by Alcoa, these gill rings, as received by Foster Wheeler, need no finishing to prepare them for assembly. Alcoa Aluminum die castings have close dimensional tolerances and smooth surfaces.

Whether you've a problem of heat transfer or a need for die castings, we are ready to serve you. Call the nearby Alcoa office, or write ALUMINUM COMPANY OF AMERICA, 2162 Gulf Building, Pittsburgh 19, Pennsylvania.

ALCOA ALUMINUM

● A plastic folding machine has been developed by the *Plastics Equipment Div., Taber Instrument Corp.,* No. Tonawanda, N. Y. With this machine plastic sheeting of from 0.005 to 0.020 in. in thickness can be folded into a "U" type-180-deg.-fold, with the sides tight together. The average operator can produce 700 formed folds an hr. with this equipment.

● A new type of coolant concentrate, known as Cool-Cut "X", has been formulated by *Paul Swartz,* 122 E. 42nd St., New York 17, for use as a coolant in the sawing, drilling, grinding and machining of plastic materials. The coolant utilizes a principle in its operation in which films of colloidal particles in effect act as ball-bearings in reducing friction at the working surfaces. The concentrate is mixed with water, 10 to 50 parts of water. Richer mixtures are used for drilling, while lean mixtures are suitable for grinding and sanding.

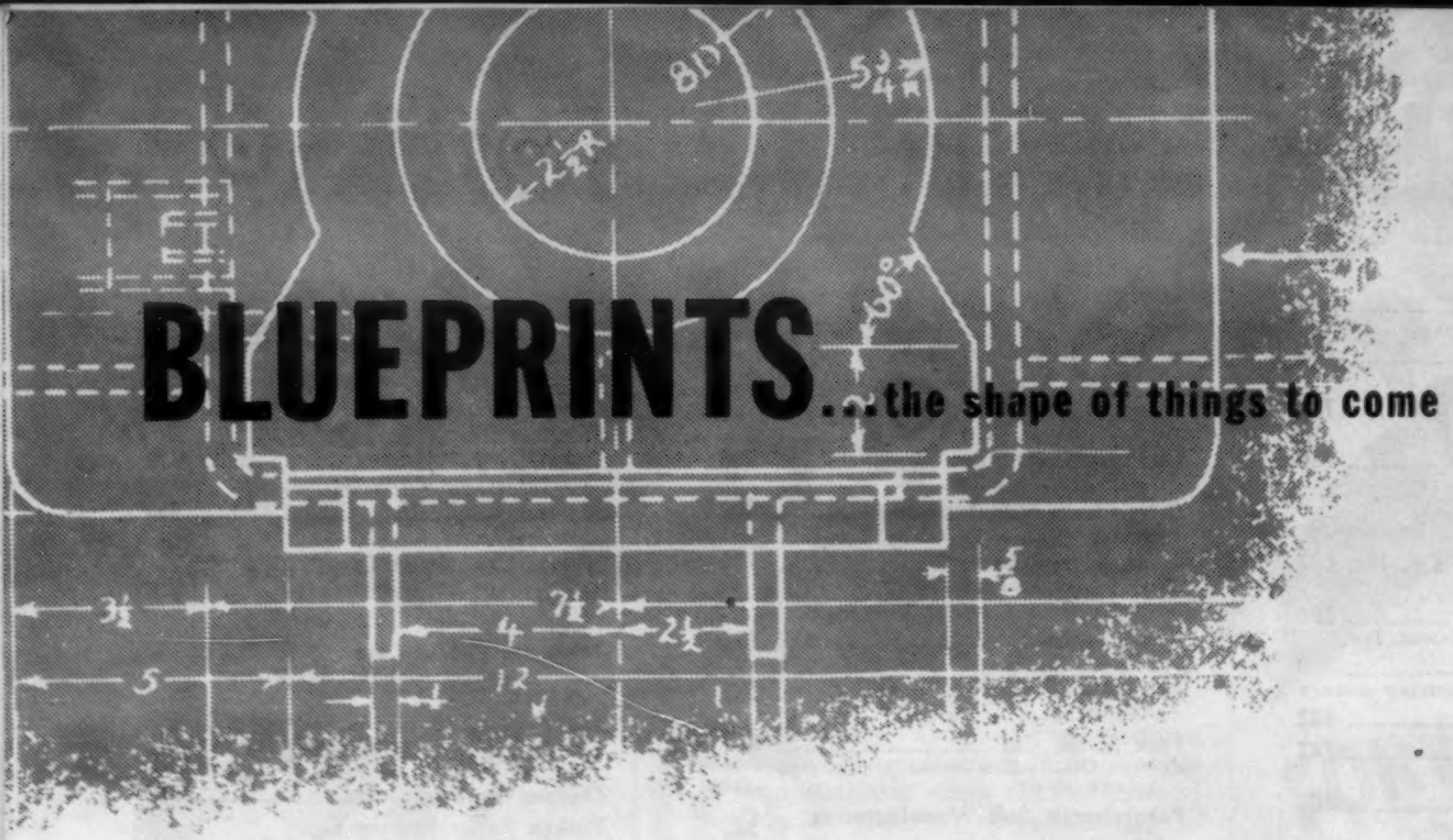
● *Sand-O-Flex Corp.,* 4373 Melrose Ave., Los Angeles, have announced a new, brush-backed sanding wheel to be identified as Sand-O-Flex Model 350-B. This wheel can be used on any electric motor shaft; a 1/6-hp. motor or a ¼-capacity electric hand drill is adequate. Recommended speed ranges from 400 to 1750 rpm.

● Development of an attachment to adapt any standard oxyacetylene welding torch for body soldering, tinning and light brazing with an acetylene-air flame, has been announced by the *Acet-A-Tip Co.,* 5069 W. Madison St., Chicago 44. The attachment is fastened to the welding torch tip by means of a base, fitted with a 2-in. length of heavy-duty two-ply hose. The hose is forced over the welding torch tip, providing positive attachment.

Correction

In the item, "New High Pressure Die Casting Machines," appearing in our July issue, the illustration of The *Hydraulic Press Manufacturing Co.* die casting machine was misplaced in relation to its description. The photograph was mistakenly positioned among the text describing the *Hydropress, Inc.* equipment.

ADVERTISERS and their AGENCIES



BLUEPRINTS...the shape of things to come

"White Carbon-Black" for Tires

Another milestone in the development of an engineering material promises to be the coloring of rubber, particularly automobile tires. Ten years of research seems about to materialize commercially, providing tires to be made the same color as automobile bodies. The new compound, which is the key chemical, is a powdery, fumed silica, obtained by subjecting sand to a long series of chemical reactions. The material has been nicknamed "white carbon-black", or "white soot". It gives the tire the same toughness as does carbon black, but without discoloration.

Aluminum Awning With Vents

So many new products have been made of aluminum that it is almost boring to mention another, but its novelty and utility make it stand out and perhaps suggest kindred uses. Expect soon a ventilated aluminum awning for windows where air is freely circulated through a series of vents and louvers which carry away solar heat and where the construction screens out direct sun rays, but admits indirect light. The inventor claims a cooling of summer temperatures of 10 to 20 F.

Tantalum Found Nearer Home

Discoveries of new sources of tantalum near Ross Lake in Northwest Canada promise more widespread use of this metal, which has proved indispensable in electronics, medical and chemical fields. It is a hard, ductile metal, resistant to most acids and inert corrosion, with high melting point. It will find favor in high temperature applications such as jet motors. Heretofore it has been obtained from Australia, Central Africa and South America.

Protective Coating for Metal

An effective temporary protective coating for metal parts, reputed to be satisfactory against rust, corrosion and salt water, may be adopted soon in this country from the Germans. It is composed of "wool fat", chinawood oil, natural resin, "white spirits," and a soluble die. It is applied with a paint brush, dries rapidly and is removed with gasoline.

Magnesium for Silent Boat Power

There is believed to be a sizeable market for a lightweight battery of a type developed during the war which moved light boats silently through the water so as to avoid enemy detection. The peace use would be for fishing, the silence not disturbing the fish. A simple rack supporting cathodes and magnesium anodes can be submerged in sea water to supply power. When power is no longer needed, the rack is raised out of the water. Additional plates can be slipped into the rack to replace worn plates even more easily than refilling a gasoline tank.

Cold-Rolled Leaded Steel

Where lead-coated steel will be used henceforth—where lead scarcity is not too prohibitive—the most technique-wise metal workers will cold roll the material after coating to cause fewer and smaller pinholes, thereby making the coating last longer. Cold reduction to an elongation of 1.5 to 2.0% is recommended by Battelle Memorial Institute. This war time "know how" is now being revealed to civilians.

Iron Powder Direct From Ore

Borrowing from the Germans, Americans may prepare iron powder directly from pulverized iron ore by reducing the ore at low temperatures. The Germans learned that the size of iron ore particles remain unchanged if the ore is reduced at 1110 to 1380 F. Thus, the particle size of powdered iron can be predetermined through pulverization of the ore. Pulverization is more readily done before reduction since ore is more easily broken up than soft iron. Reduction should be done in several stages, permitting purity removal between stages. In the early stages 1290 to 1615 F is permissible with 1110 to 1380 F finally.

New Ceramic Coatings

More details are available concerning new ceramic coatings for high temperature protection of low carbon steel, discovered by the Navy, and to be adapted to peace use, as described in these columns in July. One compounds a heterogeneous layer through mechanical admixture of calcined aluminum oxide and conventional ground coat frit. These coatings resist failure under repeated thermal shock, protect against oxidation at 1250 F, resist cracking and blistering, and produce no glare.

Cheaper Electrical Condensers

A new type of electrical or electronic condenser, as far as the U.S.A. is concerned, may have the usual metal foil replaced by a very thin, vaporized zinc coating applied directly upon the paper dielectric. It heals automatically after an electric breakdown, is 40% smaller than the paper and foil type, with production costs 20% less.

More About Tomorrow's Automobile

The not-far future light 5-passenger auto will have rubber torsion springs, independent wheel suspension and hydraulic steering. Springs may consist of rubber cylinders bonded internally to central shafts and externally to outer shells, one stationary and the other rotated by a wheel support arm. Front suspension will comprise single wheel support arms mounted diagonally from the dash on the outer member of cylindrical rubber torsion springs. Steering will be done by two balanced hydraulic circuits, one a hydraulic tie rod between the front wheels, the other a pump circuit, kept under minimum positive pressure by a spring-loaded reservoir. Rear suspension will be of the independent swinging axle type, with universal joint at each wheel.